US009370694B2

(12) **United States Patent**
Luciano, Jr. et al.

(10) **Patent No.: US 9,370,694 B2**
(45) **Date of Patent: Jun. 21, 2016**

(54) **GOLF BALL WITH RFID INLAY IN A MOLDED IMPRESSION**

(75) Inventors: **Robert Luciano, Jr.**, Reno, NV (US); **Warren White**, Reno, NV (US); **David Grieshaber**, Brisbane, CA (US)

(73) Assignee: **EDGE TECHNOLOGY**, Reno, NV (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/444,652**

(22) Filed: **Apr. 11, 2012**

(65) **Prior Publication Data**

US 2012/0256731 A1 Oct. 11, 2012

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/277,940, filed on Oct. 20, 2011, which is a continuation-in-part of application No. 13/212,850, filed on Aug. 18, 2011, and a continuation-in-part of application No. 13/212,885, filed on Aug. 18, 2011.

(60) Provisional application No. 61/374,713, filed on Aug. 18, 2010, provisional application No. 61/375,555, filed on Aug. 20, 2010.

(51) **Int. Cl.**

G08B 13/14	(2006.01)
A63B 67/02	(2006.01)
A63B 57/00	(2015.01)
A63B 37/00	(2006.01)
A63B 43/06	(2006.01)
A63B 37/04	(2006.01)
G01B 5/02	(2006.01)
A63B 43/00	(2006.01)
A63B 24/00	(2006.01)

(52) **U.S. Cl.**
CPC ***A63B 43/00*** (2013.01); ***A63B 37/0003*** (2013.01); *A63B 2024/0037* (2013.01); *A63B 2220/10* (2013.01); *A63B 2225/15* (2013.01); *A63B 2225/52* (2013.01)

(58) **Field of Classification Search**
USPC 340/572.8
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,369,812	A	2/1968	McKee
3,828,353	A	8/1974	Majkrzak et al.
3,889,957	A	6/1975	Klabacka

(Continued)

FOREIGN PATENT DOCUMENTS

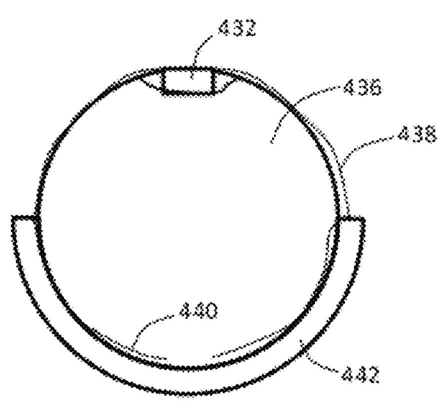
GB	2446212	A	6/2006
JP	8-224331	A	9/1996
JP	2013154176	A	8/2013

Primary Examiner — Jennifer Mehmood
Assistant Examiner — John Mortell
(74) *Attorney, Agent, or Firm* — Michael A. Kerr; Kerr IP Group, LLC

(57) **ABSTRACT**

A compressible core with an RFID tag is described. The compressible core includes an RFID integrated circuit, a carrier material, a molded compressible core, and a fill material. The RFID integrated circuit includes a memory that stores at least one unique identifier. The carrier material includes an RFID antenna electrically coupled to the RFID integrated circuit. The molded compressible core has a center and a spherical surface. Additionally, the molded compressible core includes a molded impression that receives the carrier material with the antenna and RFID integrated circuit. The fill material fills the molded impression occupied by the inlay.

15 Claims, 15 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

4,816,836	A	3/1989	Lalezari	
4,979,739	A	12/1990	Allen et al.	
5,102,140	A	4/1992	Vincent	
5,114,155	A	5/1992	Tillery et al.	
5,370,389	A	12/1994	Reising	
5,439,224	A	8/1995	Bertoncino	
5,505,457	A	4/1996	Boylan et al.	
5,513,841	A	5/1996	Takagi	
5,626,531	A	5/1997	Little	
5,674,130	A	10/1997	Egan	
5,743,815	A *	4/1998	Helderman	A63B 37/0003 473/152
5,821,525	A	10/1998	Takebayashi	
5,910,057	A *	6/1999	Quimby	A63B 24/0021 473/353
5,949,679	A	9/1999	Born et al.	
6,148,271	A	11/2000	Marinelli	
6,322,455	B1	11/2001	Howey	
6,569,028	B1	5/2003	Nichols et al.	
6,607,123	B1	8/2003	Jollifee et al.	
6,620,057	B1	9/2003	Pirritano et al.	
6,705,942	B1	3/2004	Crook et al.	
6,974,391	B2	12/2005	Ainsworth et al.	
6,998,965	B1	2/2006	Luciano et al.	
7,040,998	B2	5/2006	Jolliffe et al.	
7,052,391	B1	5/2006	Luciano, Jr.	
7,056,221	B2	6/2006	Thirkettle et al.	
7,059,974	B1	6/2006	Golliffee et al.	
7,118,105	B2	10/2006	Benevento	
7,160,196	B2	1/2007	Thirkettle et al.	
7,337,965	B2	3/2008	Thirkettle et al.	
7,540,428	B2	6/2009	Baba et al.	
7,691,009	B2 *	4/2010	Savarese	A63B 24/0021 473/152
7,741,965	B2	6/2010	Lai	
7,766,766	B2 *	8/2010	Savarese	A63B 24/0021 473/351
7,791,982	B2	9/2010	Karr	
7,843,334	B2	11/2010	Kumagai et al.	
8,120,540	B1	2/2012	Armstrong	
8,866,613	B2	10/2014	Luciano, Jr.	
8,882,606	B2	11/2014	Leech et al.	
2002/0065567	A1	5/2002	Kodera	
2003/0004005	A1	1/2003	Ainsworth et al.	
2003/0085619	A1 *	5/2003	Strache	B60C 23/0433 307/10.1
2003/0191547	A1	10/2003	Morse	
2004/0142766	A1	7/2004	Savarese et al.	
2004/0214648	A1	10/2004	Simpson	
2004/0243262	A1	12/2004	Hoffmann	
2005/0051951	A1	3/2005	Benevento	
2005/0070376	A1	3/2005	Savarese et al.	
2005/0227792	A1 *	10/2005	McCreary	A63B 24/0003 473/409
2005/0272496	A1	12/2005	Reinish et al.	
2005/0282650	A1	12/2005	Miettinen et al.	
2006/0105857	A1	5/2006	Stark	
2006/0122007	A1	6/2006	Savarese et al.	
2007/0026968	A1	2/2007	Ratcliffe	
2007/0026986	A1	2/2007	Walker	
2007/0167247	A1	7/2007	Lindsay	
2007/0259740	A1	11/2007	Savarese et al.	
2008/0000364	A1	1/2008	Bevirt	
2008/0021651	A1	1/2008	Seeley et al.	
2008/0158072	A1 *	7/2008	Logan	B60C 23/0493 343/711
2008/0207357	A1 *	8/2008	Savarese	A63B 24/0021 473/407
2009/0052618	A1	2/2009	Homanfar et al.	
2009/0253526	A1 *	10/2009	Koudele	A63B 43/00 473/155
2009/0294528	A1 *	12/2009	Halbur	G07F 7/0813 235/381
2009/0314423	A1	12/2009	Savarese et al.	
2010/0201512	A1	8/2010	Stirling et al.	
2010/0304876	A1	12/2010	Hohla et al.	
2010/0328038	A1	12/2010	Kato	
2011/0201437	A1	8/2011	Fallow et al.	
2012/0052967	A1	3/2012	Grieshaber et al.	
2012/0096358	A1	4/2012	Barnes, Jr.	
2012/0208464	A1	8/2012	Rofougaran	
2012/0208638	A1	8/2012	Barney et al.	
2012/0255998	A1 *	10/2012	Luciano, Jr.	A63B 37/0003 235/439
2012/0255999	A1	10/2012	Luciano	
2012/0256731	A1	10/2012	Luciano et al.	
2013/0023210	A1	1/2013	Rofougaran	
2013/0154176	A1	6/2013	Oshima	
2013/0165261	A1	6/2013	Luciano et al.	
2013/0196787	A1	8/2013	Luciano et al.	
2013/0196788	A1	8/2013	Shimizu et al.	

* cited by examiner

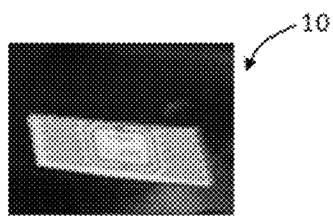


Figure 1A
(prior art)

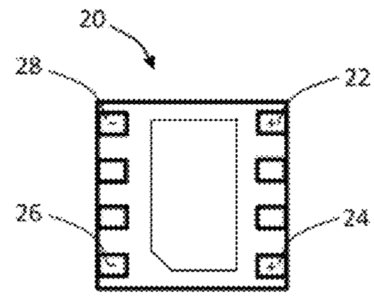


Figure 1B
(prior art)

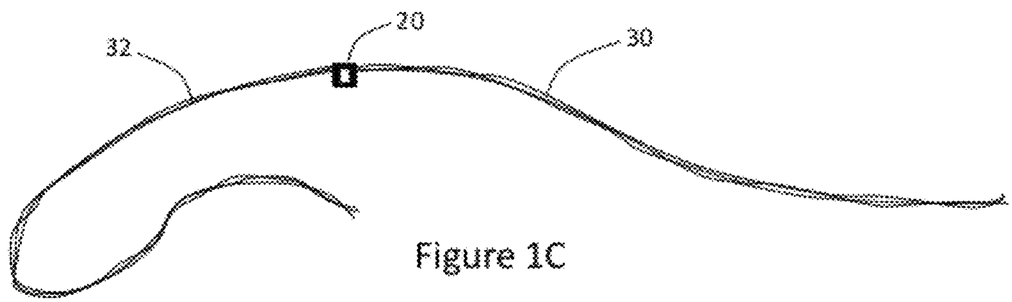


Figure 1C

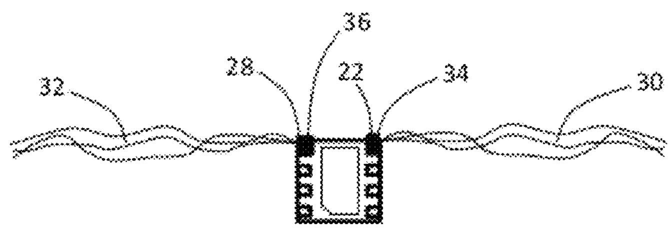


Figure 1D

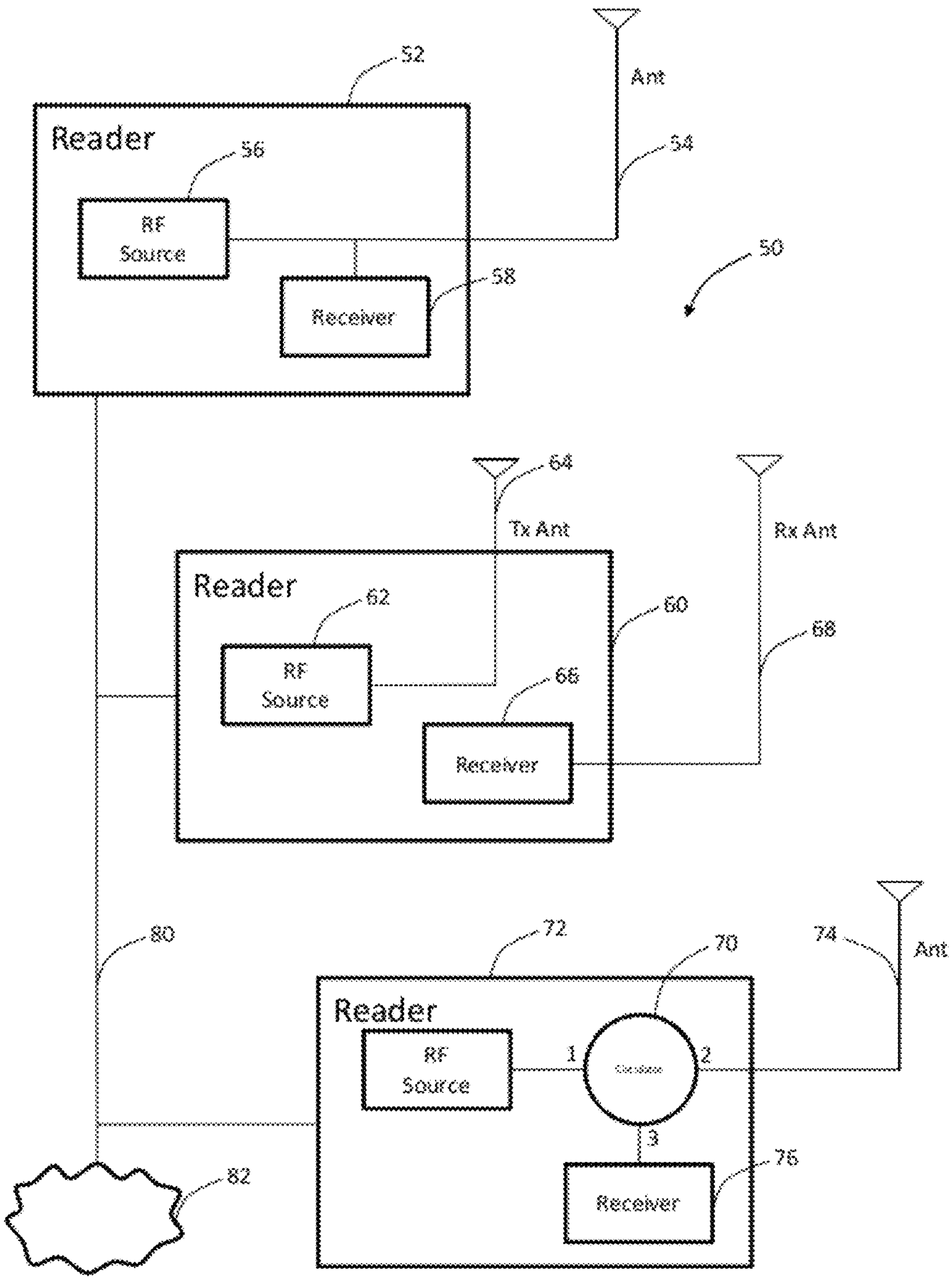

52
Reader
56
RF
Source
Receiver
58
Ant
54
50
64
Tx Ant
Rx Ant
Reader
62
60
68
RF
Source
66
Receiver
80
72
70
74
Ant
Reader
RF
Source
1
2
3
76
Receiver
82

Figure 2

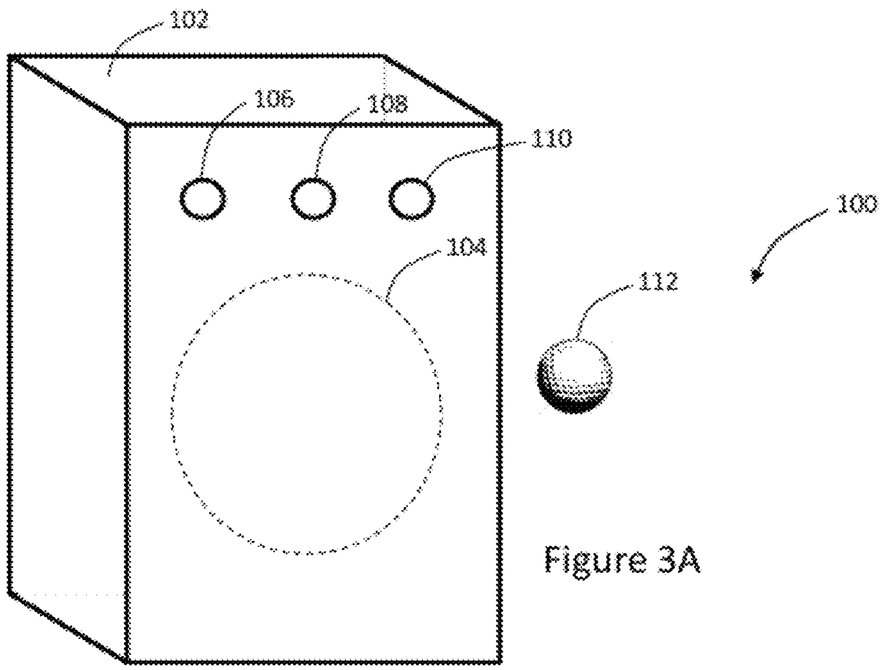


Figure 3A

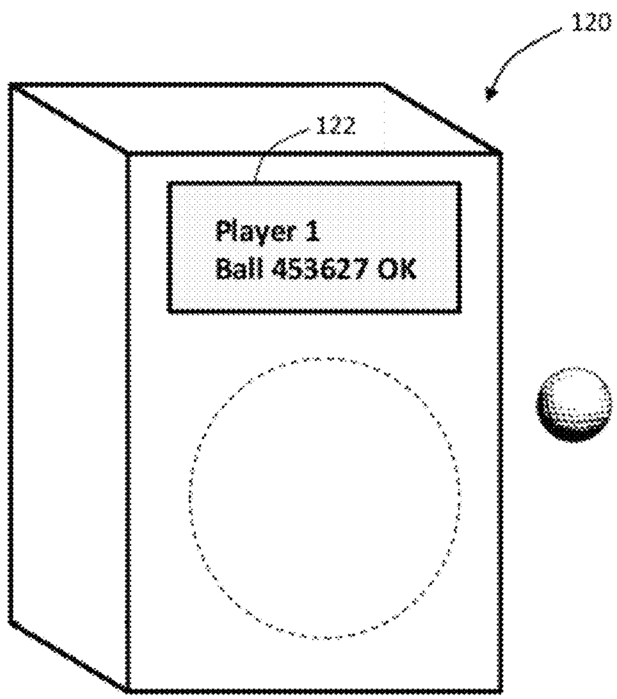


Figure 3B

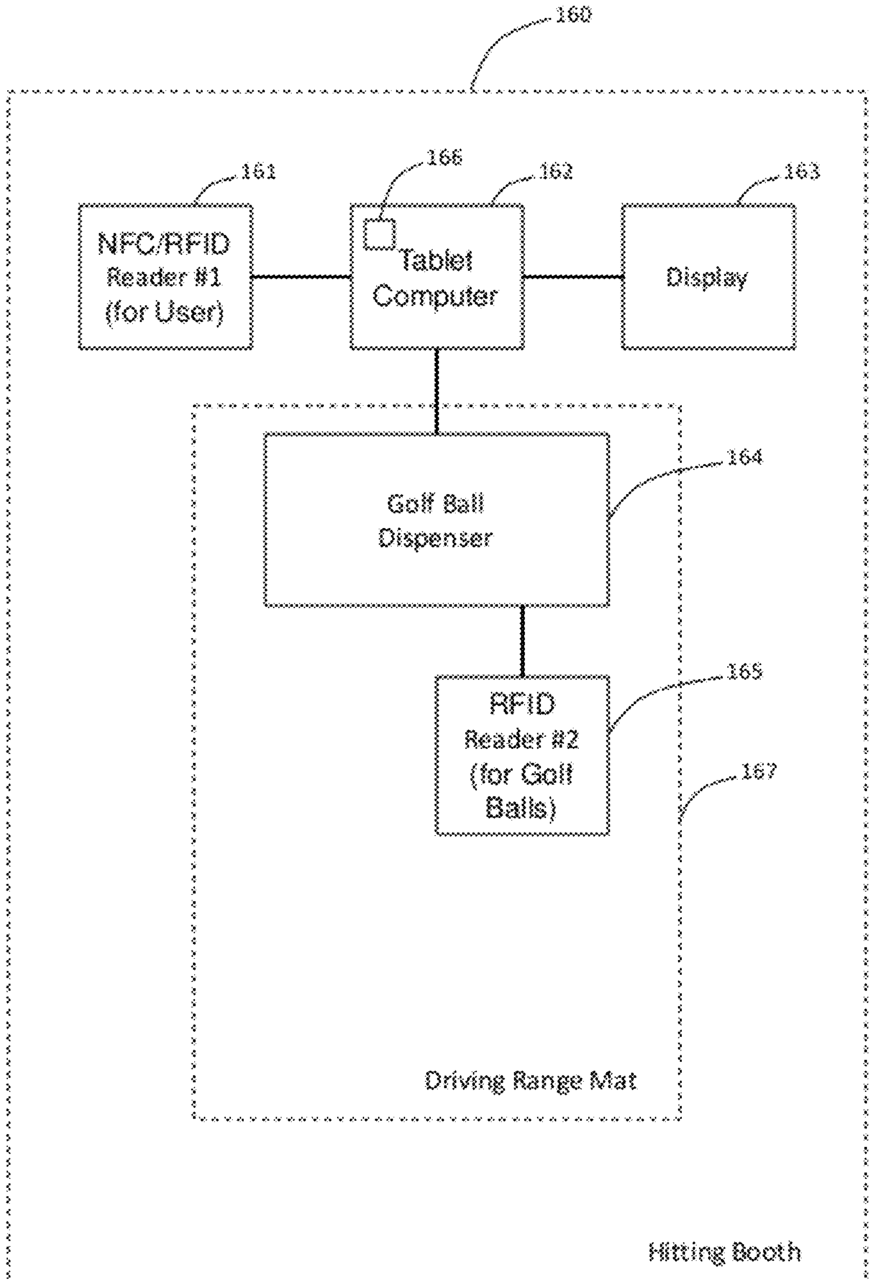

160
161
166
162
163
NFC/RFID
Reader #1
(for User)
Tablet
Computer
Display
164
Golf Ball
Dispenser
165
RFID
Reader #2
(for Golf
Balls)
167
Driving Range Mat
Hitting Booth

Figure 4

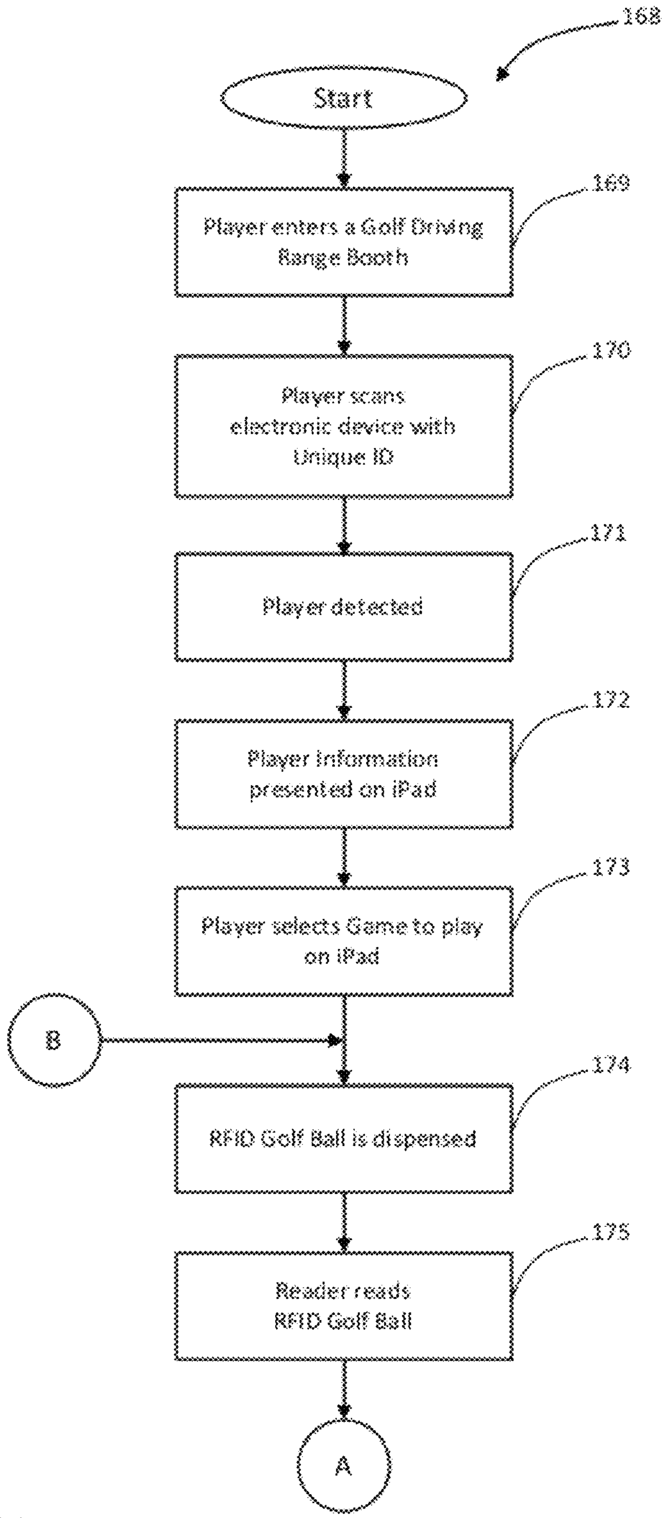

168
Start
Player enters a Golf Driving Range Booth
169
Player scans electronic device with Unique ID
170
Player detected
171
Player Information presented on iPad
172
Player selects Game to play on iPad
173
B
RFID Golf Ball is dispensed
174
Reader reads RFID Golf Ball
175
A

Figure 5A

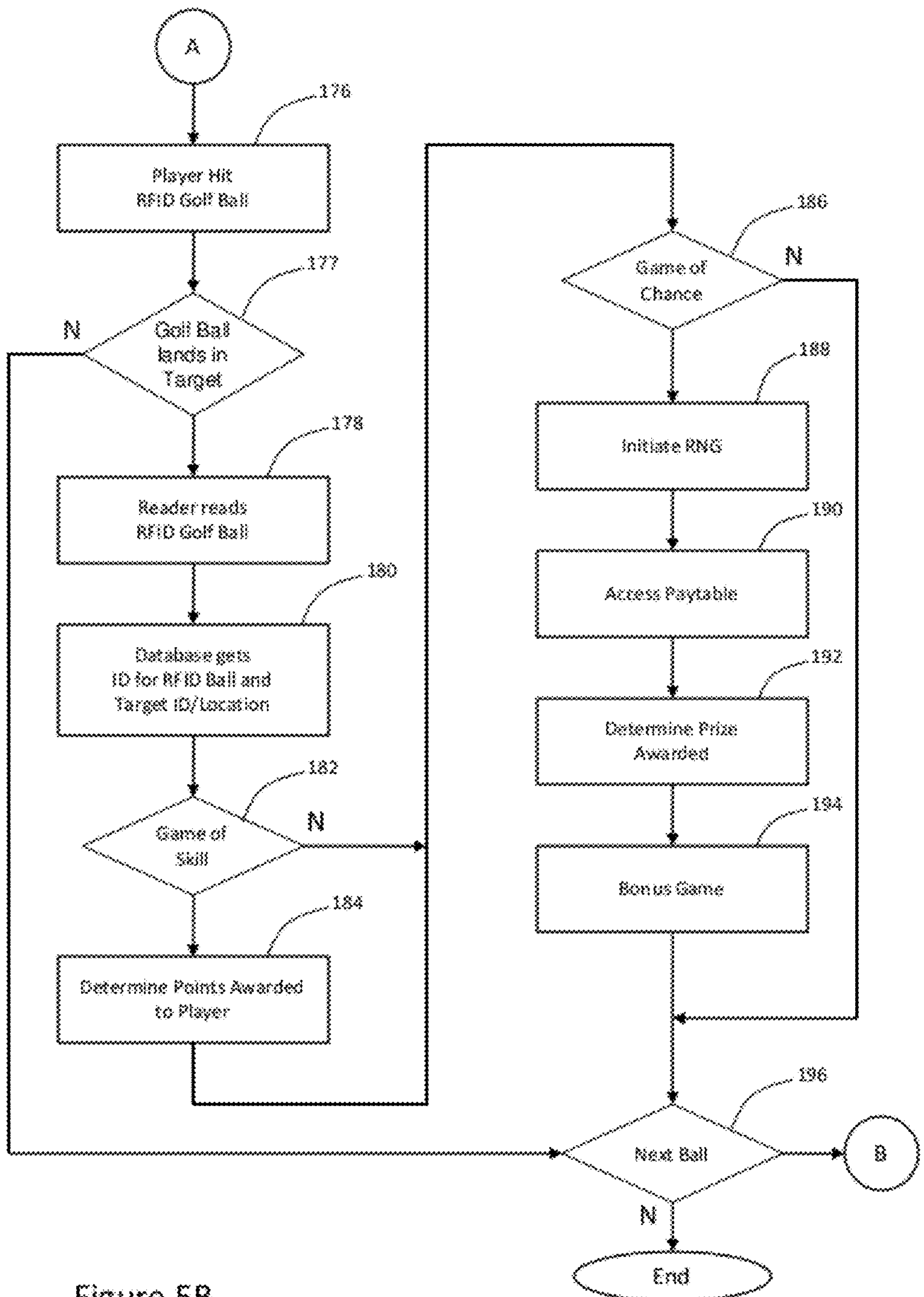

A
176
Player Hit RFID Golf Ball
177
Golf Ball lands in Target
N
178
Reader reads RFID Golf Ball
180
Database gets ID for RFID Ball and Target ID/Location
182
Game of Skill
N
184
Determine Points Awarded to Player
186
Game of Chance
N
188
Initiate RNG
190
Access Paytable
192
Determine Prize Awarded
194
Bonus Game
196
Next Ball
B
N
End

Figure 5B

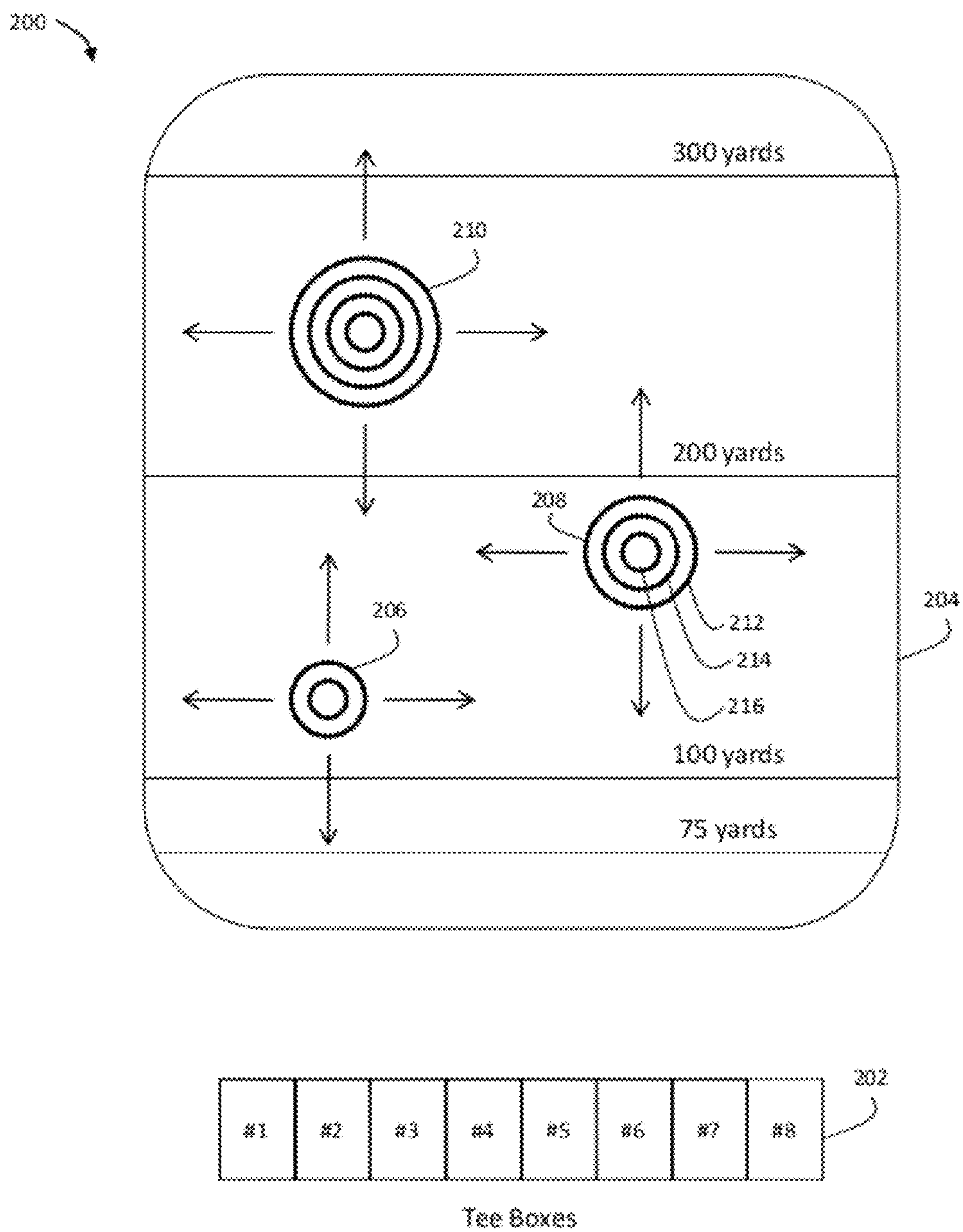

200
300 yards
210
200 yards
208
206
212
214
216
204
100 yards
75 yards
#1
#2
#3
#4
#5
#6
#7
#8
202
Tee Boxes

Figure 6

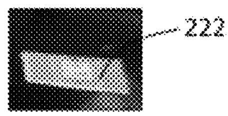


Figure 7A

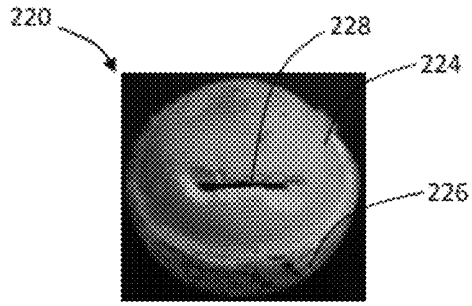


Figure 7B

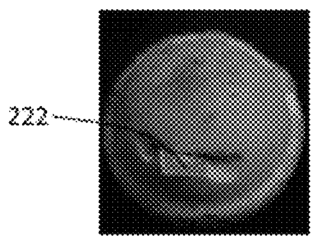


Figure 7C

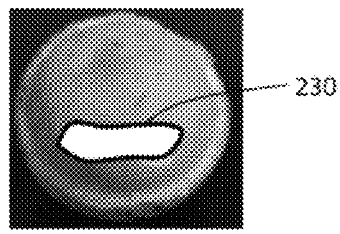


Figure 7D

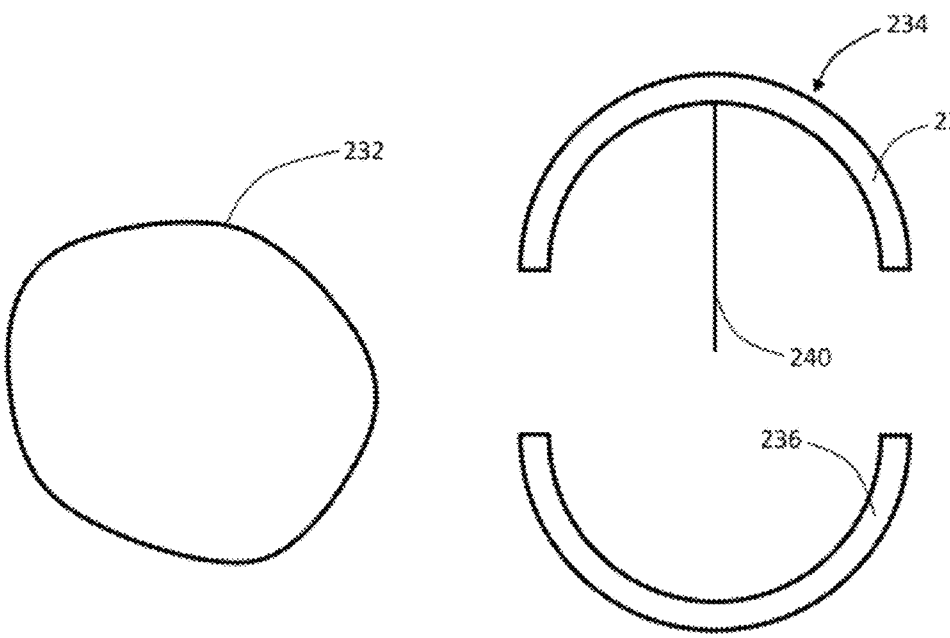


Figure 7E

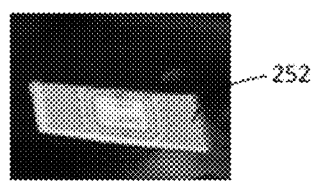


Figure 8A

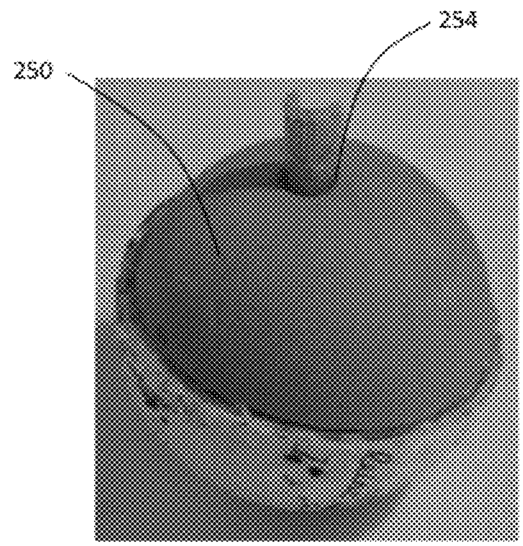


Figure 8B

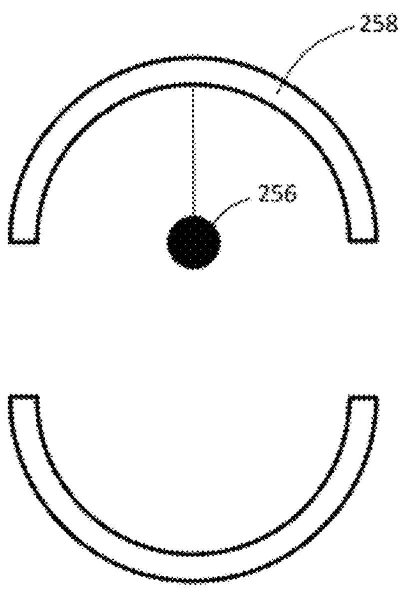


Figure 8C

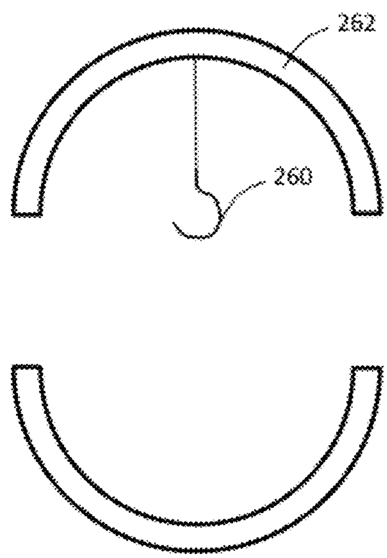


Figure 8D

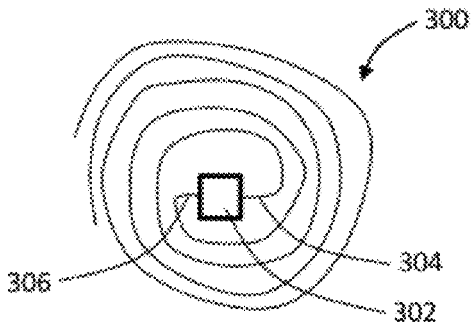


Figure 9A

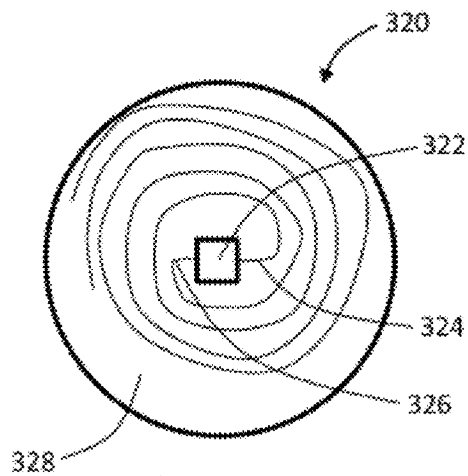


Figure 9B

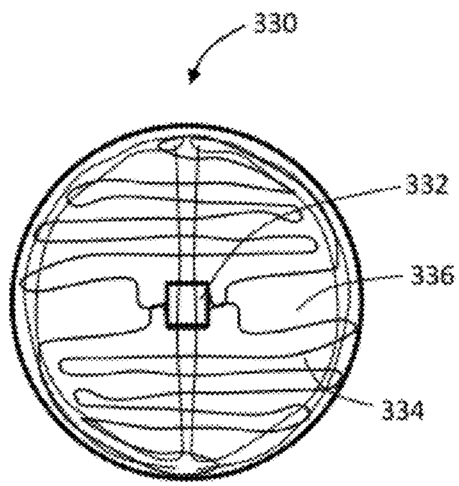


Figure 9C

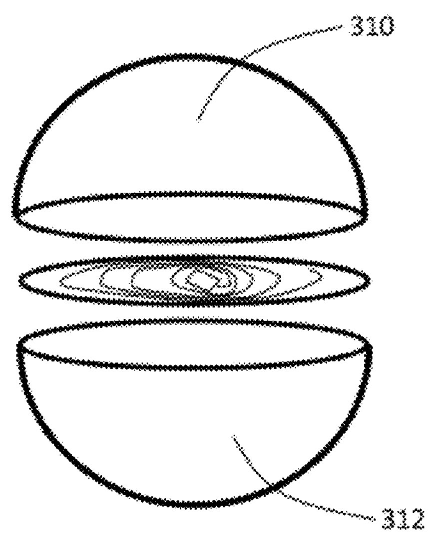


Figure 9D

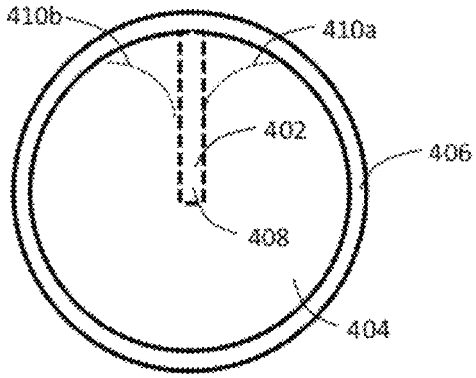


Figure 10A

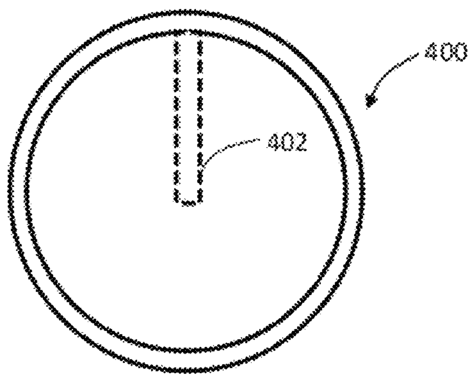


Figure 10B

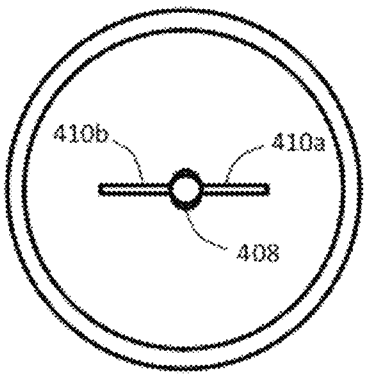


Figure 10C

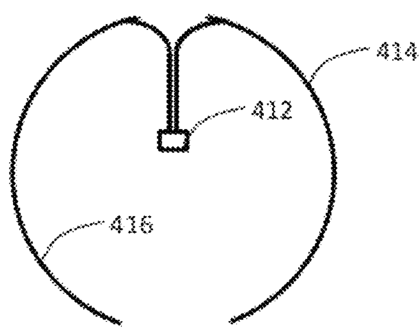


Figure 10D

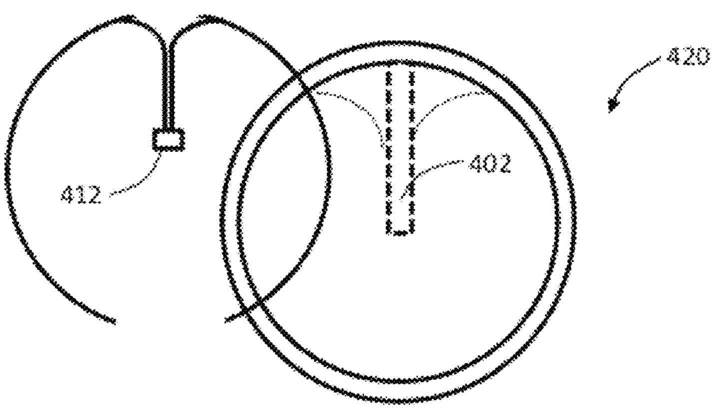


Figure 10E

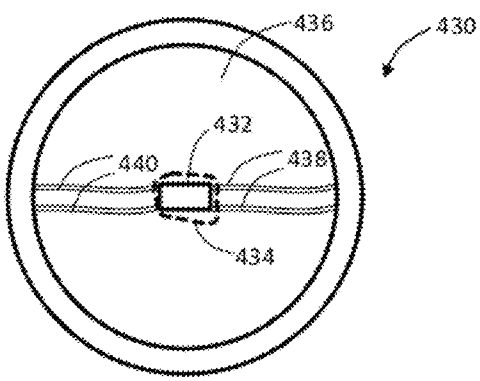


Figure 11A

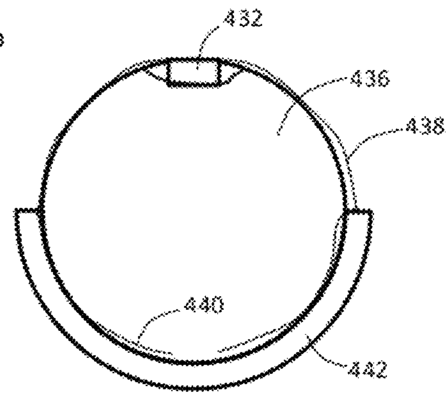


Figure 11B

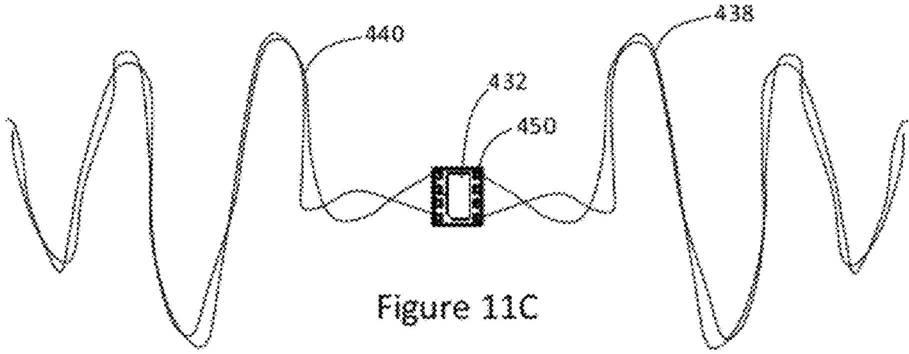


Figure 11C

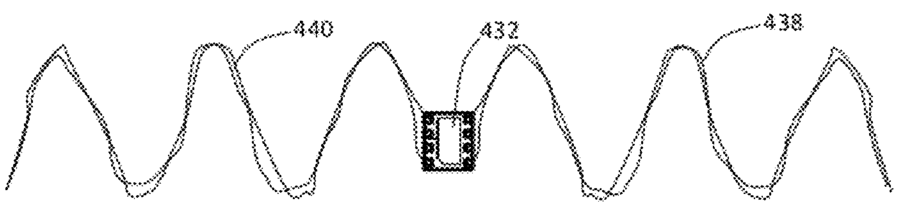


Figure 11D

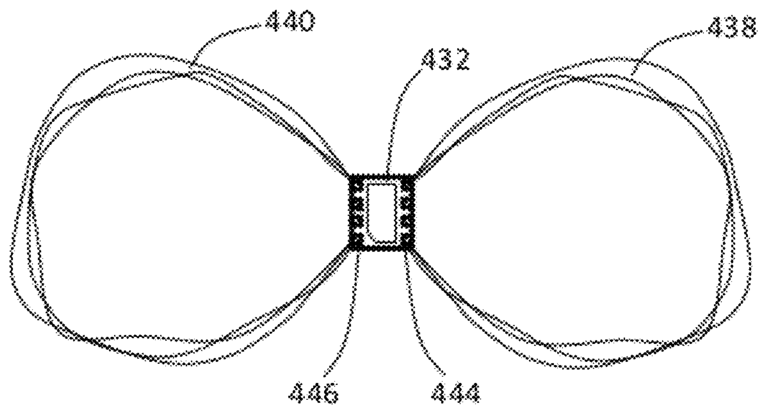


Figure 11E

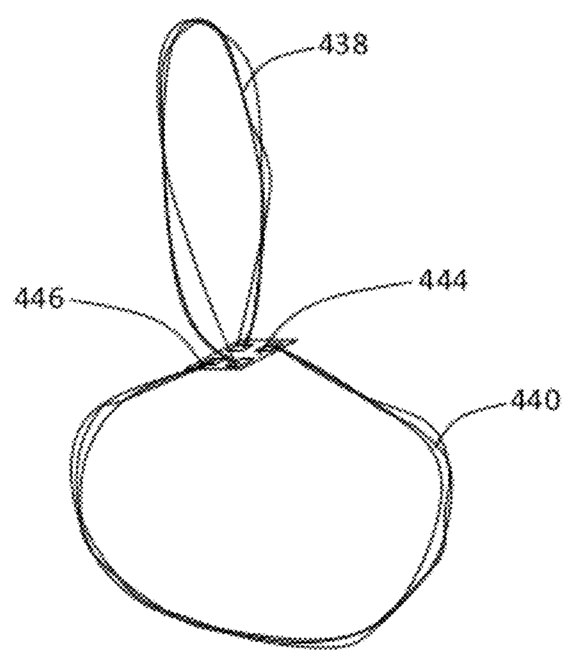


Figure 11F

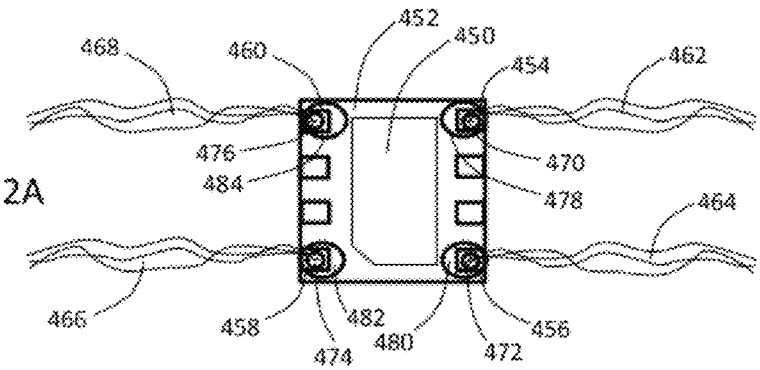


Figure 12A

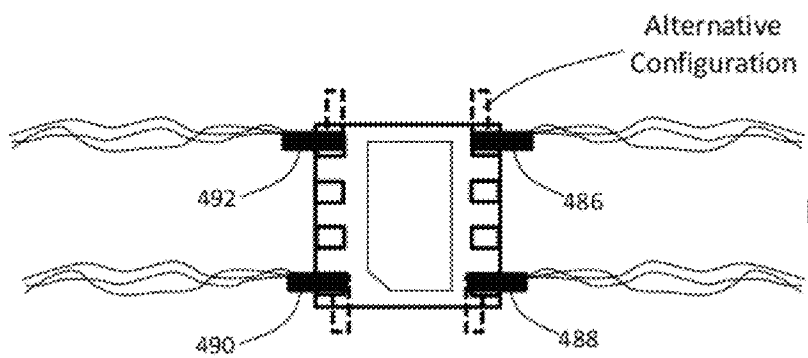


Figure 12B

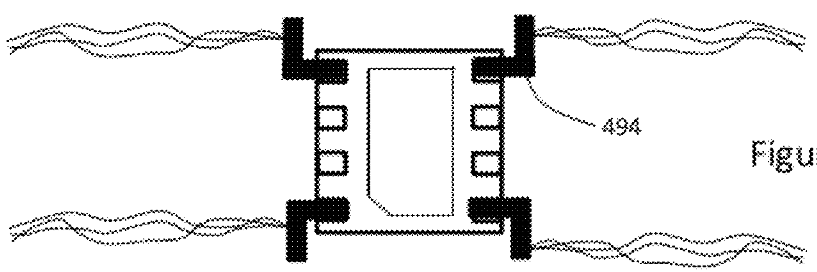


Figure 12C

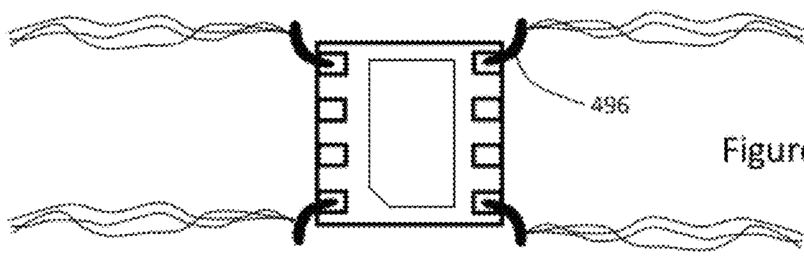


Figure 12D

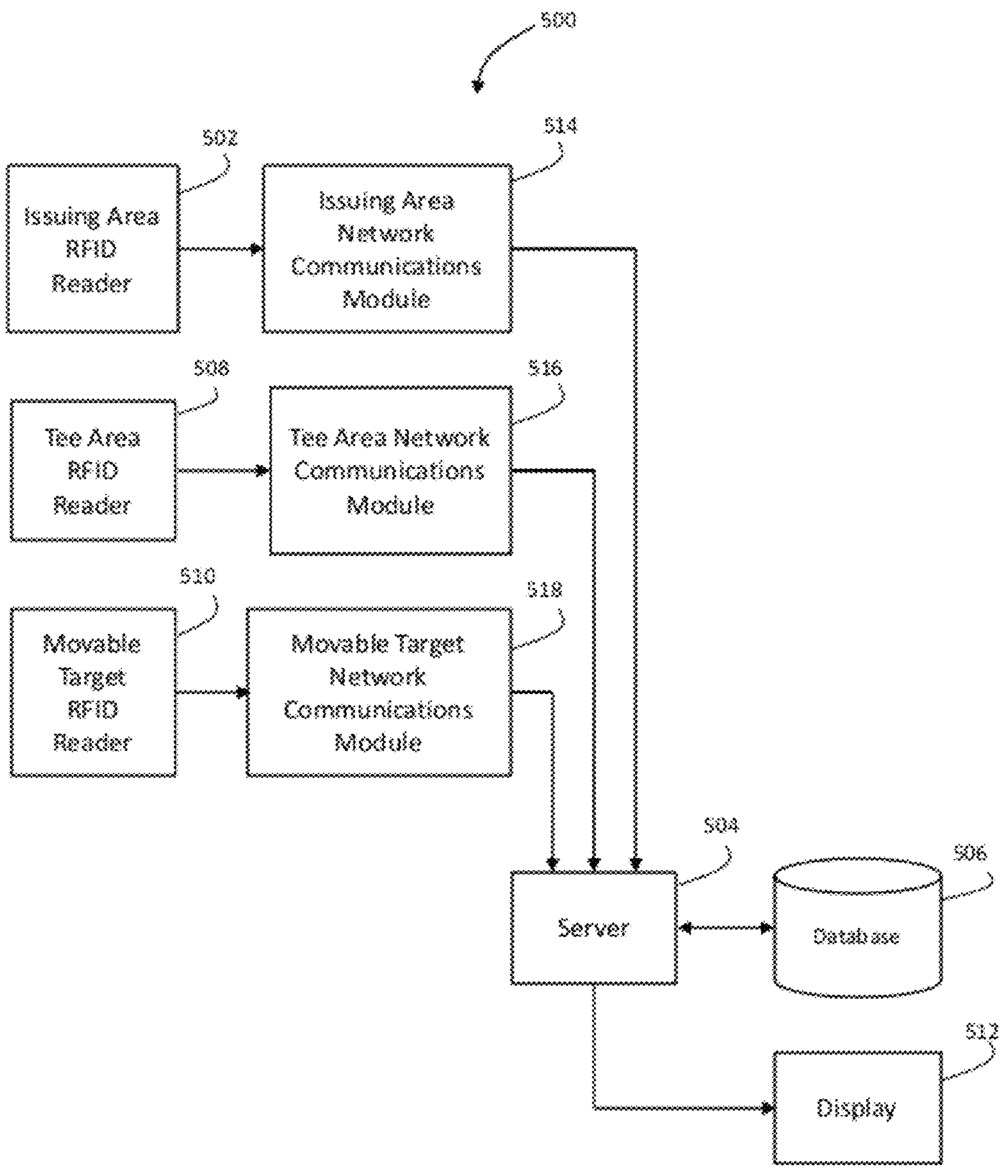

500
502
Issuing Area RFID Reader
514
Issuing Area Network Communications Module
508
Tee Area RFID Reader
516
Tee Area Network Communications Module
510
Movable Target RFID Reader
518
Movable Target Network Communications Module
504
Server
506
Database
512
Display

Figure 13

GOLF BALL WITH RFID INLAY IN A MOLDED IMPRESSION

CROSS REFERENCE

This patent application is a continuation-in-part of Ser. No. 13/277,940 filed on Oct. 20, 2011 and entitled RFID GOLF BALL TARGET SYSTEM AND METHOD which is a continuation-in-part of utility patent application Ser. No. 13/212,850 filed on Aug. 18, 2011 and entitled BALL SEPARATION DEVICE FOR A GOLF RANGE TARGET and is a continuation-in-part of utility patent application Ser. No. 13/212,885 filed on Aug. 18, 2011 and entitled MOVABLE GOLF RANGE TARGET WITH RFID BALL IDENTIFIER; and both patent applications claim the benefit of provisional patent application 61/374,713 filed on Aug. 18, 2010 and entitled MOVABLE GOLF RANGE TARGET WITH RFID BALL IDENTIFIER and claims benefit of provisional patent application 61/375,555 filed on Aug. 20, 2010 and entitled BALL SEPARATION DEVICE FOR A GOLF RANGE TARGET. All patent applications identified above are hereby incorporated by reference.

FIELD

The present invention relates to a golf ball with an RFID tag received by a compressible core that has a molded impression. More particularly, the invention is related to an RFID golf ball that includes a specially molded core that receives the RFID tag.

The present invention relates to a golf ball with an RFID tag between split core. More particularly, the invention is related to splitting the core of a golf ball and then sandwiching an RFID tag between the top hemisphere and bottom hemisphere.

The present invention relates to a golf ball with an encapsulated RFID chip. More particularly, the invention is related to an RFID golf ball that includes an encapsulated RFID chip having contact pads that are electrically coupled to an antenna, which are received by a specially molded core, and a target system and method that identifies golf balls in games of skill, games of chance, and any combination thereof.

BACKGROUND

Radio Frequency Identification (RFID) tags contain at least two parts: first, an integrated circuit for storing and processing information, modulating and demodulating a radio-frequency (RF) signal, collecting DC power from the incident reader signal, and other specialized functions; and second, an antenna for receiving and transmitting the signal.

Radio Frequency Identification (RFID) tags are capable of uniquely identifying an object via a pre-programmed response when queried by an external radio frequency wave. However, not all RFID tags are the same, as some are equipped with a transponder ID (TID) by the manufacturer. This TID is usually written to a chip at the point of manufacture, and not alterable. Additionally, some ultrahigh-frequency (UHF) tags can store a 64-bit, 96-bit or 128-bit serial number. These can be read-only or read/write. Others also have blocks of user memory that can be written to and locked, or rewritten over and over.

Signaling between the reader and the tag is done in several different incompatible ways, depending on the frequency band used by the tag. Tags operating on LF and HF frequencies are, in terms of radio wavelength, very close to the reader antenna; less than one wavelength away. In this near field region, the tag is closely coupled electrically with the transmitter in the reader. The tag can modulate the field produced by the reader by changing the electrical loading the tag represents. By switching between lower and higher relative loads, the tag produces a change that the reader can detect. At UHF and higher frequencies, the tag is more than one radio wavelength from the reader and it can backscatter a signal. Active tags may contain functionally separated transmitters and receivers, and the tag need not respond on a frequency related to the reader's interrogation signal.

An RFID system uses RFID tags that are attached to the objects to be identified. In operation, an RFID reader sends a signal to the tag and reads its response. The readers generally transmit their observations to a computer system running RFID software or RFID middleware.

The RFID tag's information is stored electronically in a non-volatile memory. The RFID tag includes a small RF transmitter and receiver. The RFID reader transmits a radio signal to interrogate the tag. The RFID tag receives the message and responds with its identification information.

RFID tags can be passive or active. Tags may either be read-only, having a factory-assigned serial number that is used as a key into a database, or may be read/write, where object-specific data can be written into the tag by the system user.

Although RFID tags have been used in golf balls previously, there continues to be problems with separation between the antenna portion and the RFID integrated circuit. When the RFID antenna is separated from the RFID integrated circuit, the RFID golf ball cannot be read. Additionally, RFID golf balls appear to have a noticeably different trajectory when struck than a standard golf ball.

SUMMARY

An RFID golf ball system and method is described. The RFID golf system includes RFID golf ball and an RFID reader antenna. The RFID golf ball further includes an RFID integrated circuit, an RFID antenna, a molded compressible core, a molded shell, and an RFID reader antenna. The RFID integrated circuit also includes a memory configured to store at least one unique identifier. The RFID antenna is electrically coupled to the RFID integrated circuit. The molded compressible core has a center, a spherical surface, and a molded impression that receives the RFID antenna and the RFID integrated circuit. The molded shell encapsulates the molded compressible core generating an RFID golf ball. The RFID reader antenna is disposed near a tee area and reads the unique identifier associated with the RFID golf ball.

In one embodiment, the RFID golf ball of the RFID golf ball system includes a conductive ink disposed on the surface of the compressible core, wherein the conductive ink is electrically coupled to the RFID integrated circuit.

In another embodiment, the RFID golf ball includes a carrier material coupled to the RFID integrated circuit and the RFID antenna. The molded impression receives the carrier material. A fill material may then be used to fill the molded impression occupied by the carrier material. For example, the molded impression includes a planar slot disposed in the center of the molded compressible core that receives a planar carrier material. In another example, the molded impression includes a curved slot disposed in the center of the molded compressible core, in which the curved slot receives a curved carrier material. In yet another example, the molded impression comprises a cylindrical slot disposed in the center of the molded compressible core, the cylindrical slot receives a curved carrier material, and the fill material fills the cylindrical slot.

A method for reading an RFID golf ball is described. The method includes dispensing an RFID golf ball within a driving range. The RFID golf ball includes an RFID integrated circuit, an RFID antenna, a molded compressible core, and molded shell. The method then proceeds to read the RFID golf ball within a driving bay with at least one RFID reader.

In one embodiment, the RFID reader includes an RFID reader antenna that is disposed above ground along a vertical plane. In another embodiment, the RFID reader includes an RFID reader antenna that is disposed along a horizontal plane.

Each RFID reader is communicatively coupled to a plurality of RFID antennas, in which each antenna corresponds to a particular golf driving bay. There are a plurality of RFID readers that are networked and communicate RFID data to a central database.

A method for embedding an RFID tag into a compressible core is also described. The method includes placing a compressible compound in a mold, where the mold includes a projection configured to leave a molded impression. The method then proceeds to heat the compressible compound in the mold. The mold is removed an a molded compressible core is generated. The molded compressible core includes a molded impression left by the mold projection. The method proceeds by placing a carrier material in the molded impression. The carrier material includes an RFID antenna electrically coupled to an RFID integrated circuit that includes a memory configured to store at least one unique identifier. A fill material is then applied to the molded impression occupied by the carrier material. The molded compressible core is encapsulated with a molded shell.

FIGURES

The illustrative embodiment will be more fully understood by reference to the following drawings which are for illustrative, not limiting, purposes.

FIG. **1**A shows an RFID tag with an inlay.

FIG. **1**B shows an encapsulated RFID tag with contacts.

FIG. **1**C shows the encapsulated RFID tag with an antenna

FIG. **1**D shows an exploded view of encapsulated RFID tag in FIG. **1**C.

FIG. **2** shows networked RFID readers.

FIG. **3**A and FIG. **3**B show an RFID reader in a vertical plane.

FIG. **4** shows system components in an illustrative golf driving range hitting booth.

FIG. **5**A shows a first portion of an illustrative method for operating an RFID golf ball range target system.

FIG. **5**B shows a second portion of the illustrative method for operating the RFID golf ball range target system.

FIG. **6** shows an illustrative driving range having movable targets.

FIGS. **7**A-**7**D show a planar molded impression in a compressible core that receives an RFID tag composed on an inlay material.

FIG. **7**E shows the mold used to generate the planar molded impression.

FIGS. **8**A-**8**B show a curved molded impression in a compressible core that receives an RFID inlay material.

FIGS. **8**C and **8**D show the mold used to generate the curved molded impression.

FIGS. **9**A-**9**D show an RFID tag sandwich between a split core.

FIGS. **10**A-**10**E show a molded impression that receives an encapsulated RFID tag with conductive wires at the center of the core.

FIGS. **11**A-**11**F show different antenna that are electrically coupled to an RFID integrated circuit disposed on a molded impression at the surface of the compressible core.

FIGS. **12**A-**12**D show a thicker wire disposed between the conductive antenna wires and the encapsulated RFID integrated circuit.

FIG. **13** presents an illustrative system diagram of the golf range target system.

DETAILED DESCRIPTION

Persons of ordinary skill in the art will realize that the following description is illustrative and not in any way limiting. Other embodiments of the claimed subject matter will readily suggest themselves to such skilled persons having the benefit of this disclosure. It shall be appreciated by those of ordinary skill in the art that the RFID golf ball systems and methods described hereinafter may vary as to configuration and as to details.

Although RFID tags have been used in golf balls previously, there continue to be problems with separation between the antenna portion and the RFID integrated circuit. When the RFID antenna is separated from the RFID integrated circuit, the RFID golf ball cannot be read. Additionally, RFID golf balls appear to have a noticeably different trajectory than a standard golf ball when struck. The amount of ball flex in a golf ball is estimated to be 0.2 inches during impact, and this impact causes separation between the antenna portion and the RFID integrated circuit, creating an RFID golf ball that cannot be read.

A variety of different RFID golf ball embodiments are presented herein including compressible core with a carrier material having an RFID integrated circuit and antenna, or an encapsulated RFID integrated circuit with conductive wires as antennas. Additionally, RFID golf ball systems and methods are presented. Furthermore, RFID golf ball reader systems are described herein.

For purposes of this patent application, the terms RFID "integrated circuit" is interchange with the term "chip." As described below, the RFID integrated circuit or chip includes a memory that stores at least one unique identifier. The term "identifier" refers to identification numbers or letters or symbols or any combination thereof.

The RFID integrated circuit may be encapsulated in a rigid or elastic material. As described in further detail, the encapsulated RFID integrated circuit includes exposed contact pads that are electrically coupled to an antenna. Illustrative materials for the rigid or elastic encapsulated RFID integrated circuit include an epoxy resin or silicon-based compound, respectively.

Additionally, term "antenna" as used herein refers to either an RFID antenna or an RFID reader antenna. Additionally, the term "antenna" is sometimes used interchangeably with materials that function as an antenna such as "conductive wires" or "conductive ink". The conductive wires or conductive ink is placed on the surface or in the center of the compressible cores.

Conductive wires operate as antennas for the encapsulated RFID integrated circuit described herein. Generally, the conductive wires are electrically coupled to the encapsulated RFID circuit with a solder that joins the surface of the contact pad and the surface of the conductive wire. By way of example and not of limitations, the material properties of the solder may include tin, lead, silver or any combination thereof,

Sometimes reference is made to an "RFID tag." The RFID tag includes both a chip and an antenna. The RFID tag may also be referred to as an "RFID inlay" or and "RFID inlay tag"

The RFID tag may also include a "carrier" or "substrate," on which the chip and antenna are disposed. The carrier or substrate may include an adhesive or may not include an adhesive.

Reference is also made to a compressible core. The term "compressible" refers to the ability of the core to be "compressed" when struck by a golf club. The term "compressible" is thus descriptive and does not depart from the fundamental material properties corresponding to or associated with the "compressible core." For example, basic concepts of stress, strain, and elastic modulus are applicable to the compressible core and its precursor, the "slug." The term "slug" refers to a pillow-shaped material that is placed inside a mold that after heating produces the compressible core. A compressible core may also be subject to stress such as tensile stress, bulk stress, and shear stress. Additionally, the terminology of "compressed" or "compressible" is also similar to "flexible," and so these terms are also used interchangely in this patent application

The "mold" described herein imparts a predominantly spherical shape to the slug material. The compressible core is primarily spherical in shape, but is also shaped to accommodate receiving the RFID chip, RFID antenna, the carrier material and any other encapsulation materials. Thus, the various configurations of RFID chip and RFID antenna can result in a customized mold. Any gaps or spaces in the customized mold impression may be filled with a fill material. The fill material has material properties similar to the compressible core.

A molded shell is also presented herein as the dimpled shell on a golf ball. The molded shell encapsulated the compressible core.

Various RFID readers are also presented herein. The RFID readers include RFID reader antennas and RFID reader transmitters. Sometimes reference is simply made to transmitter and receiver, without making reference to the RFID reader or RFID tag, because the context enables one with ordinary skill in the art to distinguish between and RFID reader Tx/Rx and the RFID tag Tx/Rx.

The illustrative RFID reader antennas presented herein are generally associated with a golf driving bay in a golf driving range. A golf driving bay is an area that is used by a player for hitting golf balls in a golf driving range. Generally, a golf driving range has a plurality of "bays" and these bays may be on a ground level or may be stacked on top of one another in a multi-level golf driving range.

Referring to FIG. **1**A, there is shown and RFID tag inlay **10**. The RFID tag generally includes a graphic overlay and an inlay, with the RFID tag inlay being the functional part of the RFID tag **10**. The RFID tag inlay **10** includes an RFID integrated circuit (IC) **12** or "chip" that is used to carry the coded information and an antenna **14** that is used to transmit and receive RF signals.

As described in further detail below, the RFID tag **10** is received by an RFID golf ball with a customized molded impression. Additionally, the RFID tag **10** may be disposed between a split core or slug

In the illustrative embodiment, the RFID tag includes an omnidirectional antenna that operates in the ultra-high-frequency (UHF) range. Additionally, the illustrative RFID tag can be encapsulated in a flexible substrate that is disposed between the spherical golf ball core and a spherical golf ball shell.

By way of example and not of limitation, the illustrative RFID tag **918** operates at the 860 MHz-960 MHz, and the size of the internal chip is 0.2 mm by 0.2 mm. The illustrative flexible substrate or "carrier" may be composed of PVC, Teslin, urethane or any such flexible material.

An alternative to the RFIG tag **10** is the encapsulated RFID tag **20** shown in FIG. **1**B. The illustrative encapsulated RFID tag **20** includes contact pads **22**, **24**, **26** and **28** that are electrically coupled to an antenna (not shown in FIG. **1**B). By way of example and not of limitation, the illustrative RFID chip is a Monza 4 Dura chip from Impinj.

The illustrative Monza 4 Dura chip is in a packaged format with a ruggedized tag design that includes the encapsulated RFID chip with a rigid material, e.g. an epoxy. The illustrative Monza 4 Dura is supported by a standard PCB surface mount assembly technique and is encased in an 8-pin μDFN package that accommodates surface mount assembly. The illustrative operating frequency is between 860-960 MHz. The package length is approximately 2 mm, width is 2 mm, and height is 0.50 mm. By way of example and not of limitation, pins **8** and **4** provide input pads for a first antenna that is isolated from the RF input pads for a second antenna that utilizes pins **1** and **5** as the input pads.

FIG. **1**C, there is shown the encapsulated RFID integrated circuit with conductive wires that operate as an antenna. In the illustrative embodiment, the Monza 4 Dura chip is integrated with a compressible golf ball core as described herein. More particularly, the encapsulated RFID integrated circuit **20** is coupled to conductive wires **30** that are electrically coupled to contacts **22**, **24** and conductive wires **32** are electrically coupled to contacts **26** and **28**.

FIG. **1**D shows an exploded view of encapsulated RFID integrated circuit in FIG. **1**C, in which the conductive wires **30** and **32** are electrically coupled to contacts **22** and **28**, respectively. The conductive wires **30** and **32** are electrically coupled to contacts **22** and **28** using a material **34** and **36**, respectively. The materials **34** and **36** may be either conductive materials, non-conductive materials or a combination thereof. The illustrative encapsulated RFID tag shown in FIGS. **1**C and **1**D are then integrated into an golf ball as described in further detail below.

Referring now to FIG. **2**, there is shown a plurality of networked RFID readers that interrogate the RFID tags described above. The interrogation is commonly accomplished by arranging the RFID tags to listen for an interrogation message and to respond with a unique serial number or other such information. The RFID tags typically have limited power available for transmitting data wirelessly to the reader.

By way of example and not of limitation, a reader operates in a backscatter mode and the RFID tags operate using the power of the received signal from the reader to transmit. The illustrative reader is configured to have a high transmission power and high sensitivity to backscattered signals from the RFID tags.

Generally, there are two types of reader systems; bistatic systems and monostatic systems. A bistatic system uses different antenna for transmission and reception, and the antennas are sufficiently separated in space to have fewer isolation problems.

A monostatic system uses the same antenna, or collocated antenna, for transmission and reception. When the same antenna is used for both transmission and reception, a monostatic system may use only half of the number of antenna that is used in a bistatic system and cover the same area. However, a monostatic system typically requires lots of tuning to isolate the transmit power and the receiver. In a typical RFID system, the transmit power of a reader may be around a watt or two, while the receiver may be expected to be sensitive to signals at microwatt levels.

Conventional RFID readers are typically designed to use one of three general approaches to transmit signals to and receive signals from one or more tags. These approaches include a single channel homodyne technique, a two-antenna bistatic technique, and a circulator device.

Illustrative RFID reader **52** uses a homodyne receiver. A homodyne receiver refers to a single channel for both the transmitted signal and the received signal and a direct down conversion of the data to baseband. The reader **52** has a single antenna **54** electrically coupled to both a RF source **56** and a receiver **58**.

The illustrative reader **60** is a bi-static system with separate antennas that are used for transmit and receive. For example, the RFID reader **60** has a radio frequency source **62** coupled to its transmit antenna **64** and a receiver **66** coupled to receive antenna **68** that receives signals.

A circulator **70** is used to separate the incoming signal (receive) from the outgoing signal (transmit), and couples the powers in a preferred direction so the receiver retains back-scatter information and the transmitter powers the tag. For example, the reader **72** includes a circulator **70** that couples power in a preferred direction, forward for transmit and power, and to the receiver **76** for the receive or reflected portion. Power to the tag passes through to the antenna **74**, and received power from the RFID tag is channeled toward the receiver block **76** after being reflected by the tag. The circulator **70** couples port **2** to port **1** to transmit signals and couples port **2** to port **3** to receive signals.

The illustrate readers **52**, **60** and **72** are communicatively coupled to a network **82** with illustrative Ethernet cables **80**.

In one embodiment, the RFID reader of the RFID ball reading system is disposed above ground along a vertical plane. In another embodiment, the RFID reader is disposed along a horizontal plane.

In the illustrative embodiment, each RFID reader is communicatively coupled to a plurality of antennas that correspond to a particular golf driving bay. Additionally, RFID readers are networked and communicate RFID data with a central database.

Additional embodiments for the RFID reader systems are presented in patent application Ser. No. 13/277,940 entitled RFID GOLF BALL TARGET SYSTEM AND METHOD, which is hereby incorporated by reference in its entirety.

Referring to FIGS. **3**A and **3**B there is shown two illustrative tee ball validators **100** and **120**, respectively. The tee ball validators **100** and **120** are configured to operate as RFID readers positioned in a vertical plane and are configured to read RFID golf balls along a vertical axis. A tee area (as described in FIG. **4** below) has a hitting surface on which the RFID golf ball is placed before it is hit by the golf club. The illustrative tee ball validator **100** or **120** positioned near the tee area. The tee ball validator **100** or **120** validates the RFID golf ball before it is struck by the player and associates that RFID golf ball with the player.

Illustrative tee ball validator **100** includes an enclosure **102**, an RFID transmit and receive antenna **104**, multiple visual indicators, **106**, **108**, **110**, and associated electronic components as described herein. The illustrative antenna (not shown) within the enclosure **102** is an antenna **104** that is designed to detect RFID tags. The RFID reader **100** is operatively coupled to a processor or controller (not shown) that provides the detection logic, which identifies the unique identifier signal embedded in the RFID golf ball **112**. In operation the RFID reader or tee ball validator **100** then forwards the unique identification number to an application processor (not shown) associated typically with a server (not shown). The RFID reader **100** communicates with a local area network using an illustrative Ethernet based system. The illustrative server runs an illustrative relational database management system that validates the player and the RFID golf ball. The tee ball validator **100** communicates with the illustrative server and receives instructions that control a player display that provides information to the player. The illustrative player display may include visual indicators **106**, **108** and **110** that may be associated with colors red, orange and green. These visual indicators present information to the player about a particular game.

The server that runs the application program for validating the RFID golf ball and validating the player may be located in a centralized location so communications for a plurality of tee ball validators can be centrally managed and controlled.

Before striking an RFID golf ball, the player must register the RFID golf ball with the system. Registration of the RFID golf ball is performed by passing the RFID golf ball in front of the RFID antenna which reads at least one unique identifier associated with the RFID golf ball.

If the RFID reader is identified as a valid RFID golf ball that is within the database. The ball is then associated with the player in that position or golf bay and the indicators are changed to let the player know that the ball is registered and ready to be hit toward the target.

If the tee ball validator is configured in the manner of FIG. **3**A, the communication with the player would be to activate an indicator specifying that the ball is registered and ready for play. As an example, one of the available indicators might be green, indicating that a valid ball has been detected and successfully registered to the player. The player would then drop the ball onto the hitting surface and hit it toward the target. If the ball does not register correctly at the tee ball validator, then the player must choose another ball before playing.

Other indicators maybe activated to alert the player that a valid ball has been detected but that the identity of the player in that position is not known, or that some other error has been detected. In an alternative form of the tee ball validator, shown in FIG. **3**B, the set of visual indicators is replaced by a visual display **122**. This could be a small video screen imbedded in the device, or a remotely positioned monitor, mobile computing device or other communication medium.

Referring to FIG. **4** there is shown an illustrative system of components in an illustrative golf driving range hitting booth or golf driving bay. Note, the terms “driving range hitting booth” and “golf driving bay” are used interchangeably for purposes of this patent. The illustrative hitting booth **160** includes a scanner **161**, a client computer **162**, a display **163**, a golf dispenser **164** and an RFID reader **165**. The illustrative scanner **161** is a Near Field Communications (NFC) reader or an RFID reader for a membership card with an RFID tag. The illustrative scanner reads an electronic device (not shown) that is associated with the particular player. The illustrative electronic device may be a wireless handset or RFID card associated with the particular player.

After the scanner **161** reads the player’s electronic device, an identification (ID) number associated with the player’s electronic device is activated in a centralized database (not shown), and the illustrative tablet computer **162** and display **163** present the player information. The illustrative client computer **162** is a tablet computer such as an iPad® manufactured by Apple Inc. Display **163** is a much larger and presents the player information to other players in proximity of the hitting booth **160**.

In operation, a player enters the golf driving range hitting booth **160**. On an illustrative client computer **162**, such as an iPad® tablet computer mounted to a support column (not shown) on one side of the booth, the player scans his or her electronic device, such as a Near Field Communications (NFC) device or a membership card with an RFID tag, with the scanner **161**. The electronic device identifies the particular player. More players can join the game at the hitting booth or via a gaming server from different booths or site locations, thereby allowing for other players from other locations to play against one another.

After the player selects a game using tablet computer **162**, an RFID golf ball is dispensed from golf ball dispenser **164**. In the illustrative embodiment, a golf ball with an UHF omni-directional RFID chip is dispensed on to a driving range mat by golf ball dispenser **164**. A more detailed description of the RFID golf ball is provided below. When the golf ball dispenser **164** dispenses the RFID golf ball, the RFID reader **165** with an RFID near field read (NFR) antenna reads the RFID golf ball. The RFID reader **165** is communicatively coupled to a network having a server that receives the RFID golf ball information. More particularly, the unique ID from the RFID tag in the RFID golf ball is read and inserted into a database table that contains the logged-in user ID. After the golf ball rolls onto the driving range mat, the golf ball is hit by the player.

The illustrative client computer **162** includes a touch screen display that allows a player to interact with a game selection module **166**. The game selection module **166** includes at least one game of skill, in which an award is provided when the RFID golf ball associated with the player ID is read by the target RFID reader that is associated with the capture area. By way of example and not of limitation, the award may be a predetermined number of points based on the distance and size of the capture area.

An alternative embodiment, the game selection modules **166** includes at least one game of chance, in which a game session for the game of chance is initiated when the RFID golf ball associated with the player ID is read by the target RFID reader, a random result for the game session is generated, and a paytable associates a prize with the random game session result. The awarded prize is then displayed to the player.

In another embodiment, the game selection module **166** includes a game that has both a first game of skill component and a second game of chance. The embodiment starts with the player, by way of example and not of limitation, hitting the ball in the target area and getting points, and a subsequent game of chance, i.e. spinning a wheel for additional points. In operation, a first award is initially provided when the RFID golf ball is received by the capture area. This first award is based on the player's skill in hitting the ball at the appropriate target. The player then has the opportunity to play a second game of chance. By way of example and not of limitation, the second game may be referred to as a bonus game, in which the bonus game is a game of chance, where the player gets to spin a wheel. The random prize corresponding to the spinning wheel is then awarded to the player. Alternative games of chance include reels in a slot machine, virtual scratcher, bingo card, lottery game or other such graphic representation of a game of chance.

In another game embodiment, after a predetermined number of misses by the player, e.g. after 20 balls have been hit but none landed in the target area, the game session for the game of chance is initiated. Therefore, the player can continue to play the game and win points, even if he or she lacks the skill necessary to hit the golf ball into the target.

In FIG. **5**A, there is shown a first portion of an illustrative method **168** for operating an RFID golf ball range target system. The method is initiated at block **169**, when the player enters a golf driving range booth. At block **170**, the player scans an electronic device with a unique ID and the player is detected at block **171**. Player information is presented at block **172**. The player then proceeds to select a game to play on a tablet computer as described in block **173**. At block **174**, the RFID golf ball is dispensed and the reader reads the RFID golf ball at block **175**.

FIG. **5**B shows a continuation of the illustrative method **168** for operating the RFID golf ball range target system. At block **176**, the player hits the RFID golf ball. The method then proceeds to decision diamond **177**, where a determination is whether the golf ball hit the target area. If the golf ball lands in a target, the RFID golf ball is channeled into another RFID NFR antenna and RFID reader computer that is connected to the network as described in further detail below.

If the RFID ball does not land in the target area, then the method proceeds to decision diamond **196**, where a new golf ball may be dispensed and zero (0) points are awarded for the missing the target area.

At block **178**, the target RFID reader(s) read the RFID golf ball. The golf balls unique tag ID is read from the golf ball and the location of the target's ID is sent to the database.

At block **180**, the database gets the ID for the RFID ball and Target ID/location. The golf unique ID is searched for and if the ball ID is found allocated to a current logged in player, a database point list algorithm determines the points for that target and an action is triggered.

At decision diamond **182**, a determination is made whether a game of skill has been initiated. If a game of skill has been initiated, an amount of points is awarded to a player at block **184**. In the illustrative embodiment, points associated with a particular target, player ID and game session are associated with the appropriate database fields.

At decision diamond **186**, a determination is made whether a game of chance has been initiated. In first game of chance embodiment, when the RFID golf ball lands in a target, a slot machine reel spins on the tablet client computer **162** and display **163** at the players hitting booth **160**. The awarded points are then calculated in the database for that player and posted to the player's displays, on a web site and various displays throughout the facility (like a leader board).

In another game of chance embodiment, an illustrative random number generator is initiated is initiated at block **188**. At block **190**, the appropriate paytable is accessed for the particular game of chance. The prize that is awarded according to the paytable is determined at block **192**. At block **194**, an illustrative bonus game is initiated.

At decision diamond **196**, a determination is made whether to play the next ball. The database of points for the active player is then displayed in a game format on the tablet and display at the hitting booth, on a web site and various displays throughout the facility (like a leader board).

Referring to FIG. **6**, an illustrative driving range **200** having movable targets is shown. Tee area **202** has tee boxes numbered #1 through #8. A player enters one of the tee boxes and hits a golf ball from the tee box onto the target area **204**, with the objective of hitting a ball into one of the movable targets. Movable targets **206**, **208**, and **210** are shown. The arrows shown adjacent to the targets indicate that the targets are movable. Any of the targets may be relocated to any position on the target area **204**.

The movable targets include at least one enclosed boundary capture component having a top boundary edge, a bottom boundary edge, and a tapering surface material that joins the top boundary edge to the bottom boundary edge. By way of example and not of limitation, the tapering surface material may be composed of a plastic UV resistant material. The shape of the enclosed boundary components can include curved sectors or segments that are connected to one another resulting in a variety of different sizes and shapes. Thus, the shape of the enclosed boundary capture component is determined by engineering and design constraints.

If the player is aiming for target **208**, the player will be awarded a point value for landing a ball in exterior funnel **212**. A higher point value is awarded for landing the ball in inner funnel **214**. The highest point value for target **208** is awarded when the player is able to land a ball in innermost funnel **216**. In one embodiment, the target is a fixed target and includes RFID antennas under turf such as Astroturf. The RFID antennas are then associated with a particular RFID reader.

Referring to FIG. **7**A-**7**D, there is shown a planar molded impression in a molded compressible core **220** that receives an RFID tag. The RFID tag **222** includes an RFID integrated circuit with a memory as described above that includes at least one unique identification number. The RFID tag **222** also includes an RFID antenna electrically coupled to the RFID integrated circuit.

In FIG. **7**B, a compressible core **224** is shown. Additionally, a portion of molded shell **226** for the RFID golf ball is also shown. A molded impression **228** is configured to received the RFID tag inlay **222**, as shown in FIGS. **7**C and **7**D. The molded flexible core has a center and a spherical surface. Additionally, the molded impression receives the inlay material with the antenna and RFID integrated circuit. In this embodiment, the molded impression **228** is a planar slot disposed in the center of the molded flexible core. More generally, the planar slot receives a planar inlay material, e.g. RFID tag inlay **222**, which includes an antenna electrically coupled to the RFID integrated circuit. In FIG. **7**D, there is also shown a fill material **230** that is used to fill any gaps in the molded impression that receives the RFID tag inlay **232**.

One of the most important elements of the RFID tag inlay is the selection of the adhesive. In one embodiment, the antenna may be electrically coupled to the RFID integrated circuit with an anisotropic conductive adhesive. Additionally, the antenna may be electrically coupled to the RFID integrated circuit with a non-conductive adhesive.

In operation the RFID golf ball **220** is read by an RFID ball reading system that includes an RFID reader as described in FIGS. **2**-**5** and FIG. **13**.

A method for embedding an RFID tag begins with an extruded slug **232** being placed in a core mold tray that includes a mold **234** as shown in FIG. **7**E. The mold **234** includes a lower mold portion **236** and an upper mold portion **238**. The upper mold portion **238** further includes a planar projection **240**. The slug is a compressible compound that is heated to generate the compressible core of the golf ball.

By way of example and not of limitation, the planar projection **240** leaves a molded impression that has an Illustrative size of 30 mm deep×9 mm wide×0.5 mm high. In operation, the planar projection **240** may be a heated metallic projection that is blade-shaped. After the core has cooled, the RFID tag inlay is inserted into the molded impression.

After the compressible compound in the mold is heated and the mold is removed, the planar projection **240** leaves the planar molded impression **228**. The RFIG tag inlay **222** is then placed in the molded impression. A fill material is then applied that fills the molded impression occupied by the RFID tag inlay **222**. The molded flexible core **224** is then encapsulated with a molded shell, which is the cover of the golf ball.

After the RFID chip is placed in the slot, there may be a need for a filler material to be included. The filler material may be rubber like. Additionally, the material such as use teslin (which is 60% air) may be used as filler material.

Various engineering constraints that affect the design of the RFID golf ball include selection of the integrated circuit or "chip" characteristics such as memory, processor, performance, price, and how the chip and the antenna are electrically coupled, including RFID tag inlay or packaged die with soldered leads as described below.

In the illustrative embodiment, the RFID tag inlay includes an integrated circuit or "chip" or "die" and an antenna. The antenna may be composed of aluminum, copper, or silver and is bonded to a polyethylene terephthalate (PET) layer that is delivered to the label maker "dry" (without adhesive) or "wet" (attached to a pressure sensitive liner). The inlay is adhered to the back side of the label and printed and encoded in an RFID printer.

Adhesive materials can be used to attach dies onto antenna to build the inlays. In one embodiment, an interconnect adhesive is used to attach a small bare die directly to an antenna. In another embodiment, an interconnect adhesive is first used to build a much larger packaged die, which is then adhered onto an antenna. Both methods of assembly have been successfully employed to make RFID tags.

Generally, the RFID tag may also include a "carrier" or "substrate" on which the chip and antenna are disposed. The carrier or substrate may include an adhesive. For example, anisostropic conductive adhesives can be used to attach bare dies to antenna substrates. Anisotropic conduct in only one direction and is filled with small amounts of electrically conductive particles. Nonconductive adhesives may also be used to attach small dies on to to an antenna, in which die bumps are directly connected to the antenna pads using mechanical means. The nonconductive adhesive provides structural support and increases tag reliability.

Referring to FIG. **8**A-**8**B, there is shown a curved molded impression in a compressible core **250** that receives an RFID inlay tag **252**. The circular molded impression **254** is disposed in the center of the molded flexible core **250**. The curved molded impression **254** receives the curved RFID inlay tag **252** that includes a curved antenna electrically coupled to the RFID integrated circuit.

The molded impression **254** may also be a cylindrical slot disposed in the center of the molded flexible core. The cylindrical slot **254** receives a curved inlay material that includes a curved antenna electrically coupled to the RFID integrated circuit. A fill material (not shown) fills the cylindrical slot **254**. Generally, the fill materials has material properties that are similar to the compressible core material.

Referring to FIG. **8**C, there is shown a cylindrical projection **256** in a top mold portion **258**. The cylindrical projection **256** leaves a cylindrical mold impression **254** that is filled with an RFID inlay tag **252** and the appropriate fill material.

In FIG. **8**D, there is shown a curved projection **260** that is associated with a top mold portion **262**. The curved projection **260** generates a curved mold impression **254** that is configured to receive the RFID inlay tag **252**. Additionally, a fill material may be used to occupy any remaining space in the curved mold impression **254**.

Referring to FIGS. **9**A-**9**C, there is shown various RFID tags that are sandwiched between a split compressible core as shown in FIG. **9**D. In FIG. **9**A there is shown an RFID tag **300** that includes an RFID integrated circuit **302**, a first conductive wire **304** and a second conductive wire **306**. There is no substrate or carrier in FIG. **9**A. The conductive wires **302** and **304** may be a single conductive wire or may include multiple stranded wires. In FIG. **9**A, there is no inlay and the wires are shown in a top view, so the combination of the RF integrated circuit and conductive wire(s) is along a plane that can be disposed between a top hemisphere **310** and bottom hemisphere **312** presented in FIG. **9**D.

Referring now to FIG. **9**B, there is shown an RFID tag **320** that includes an RFID integrated circuit **322**, a first conductive wire **324**, a second conductive wire **326**, and a carrier or substrate **328**. The conductive wires **324** and **326** may be a single conductive wire or may include multiple stranded wires. In FIG. **9**B, there is a carrier that is coupled to the conductive wires **324** and **326** as a dry inlay (no adhesive) or as a wet inlay (with adhesive). FIG. **9**B presents a top view so the combination of the RF integrated circuit and conductive wire(s) are along a plane that can be disposed between the top hemisphere **310** and bottom hemisphere **312** presented in FIG. **9**D.

Referring to FIG. **9**C, there is shown an RFID tag inlay **330** that includes an RFID integrated circuit **332**, a printed antenna **334**, and a carrier **336** that are coupled together as a dry inlay or as wet inlay. By way of example and not of limitation, the carrier material may be composed of a very light substrate such as a low-density or high-density polyethylene compound. FIG. **9**C presents a top view of the RFID tag inlay that is placed between the top hemisphere **310** and bottom hemisphere **312** presented in FIG. **9**D.

The RFID tag sandwiched between the top hemisphere **310** and the bottom hemisphere **312** is then placed in a mold (not shown) that includes a lower tray (not shown) and upper tray (not shown). The mold is then heated and the top hemisphere **310** and bottom hemisphere **312** are melted so that the appropriate RFID tag inlay (**300**, **320** or **330**) is encased within a newly pressed spherical compressible core that is then encased or encapsulated by a dimpled molded covering or shell.

In each of the split core embodiment, after the RFID chip has been sandwiched between hemispheres, the combination of half cores, RFID chip, and antenna are then placed in the apppriate mold and reheated. The reheat temperature is dependent on material properties of the core, the RFID chip, the antenna, and the carrier. For illustrative purposes, reheat is performed at 130° C.-204° C. and depends on the amount of applied pressure. In a more narrow embodiment, the reheat temperature of 204° C. (400 F) is applied for 15-25 minutes.

Alternatively, a slug as shown in FIG. **7**E above may be split into two sections and the carrier material having the RFID chip and antenna disposed thereon can be sandwiched between the two slug sections. The split slug with the sandwiched RFID tag may then be placed in a mold that is heated to form a compressible core with an embedded RFID tag.

Referring to FIG. **10**A-**10**E, there is shown a molded impression that receives an encapsulated RFID tag at the center of the compressible core. More particularly, in FIG. **10**A there shown a side view of a molded impression **402** that extends to the center of the compressible core **404**. A molded shell **406** further encapsulates the compressible core **404**. The illustrative molded impression **402** includes a round hole **408** that extends to the center of the core **404**. Additionally, the molded impression includes side wings **410***a* and **410***b* that are adjacent to the round hole **408**.

In FIG. **10**B, another side view is presented that is 90° from the FIG. **10**A. In this second side view, the side wings **410***a* and **410***b* and the round hole **408** associated with molded impression **402** are in the same plane.

In FIG. **10**C, a top view is presented of the molded impression **402** that includes the rounded hole **408** and side wings **410***a* and **410***b*.

FIG. **10**D presents an encapsulated RFID integrated circuit **412** that is electrically coupled to antenna **414** and **416**. The RFID chip **412** fits into the center of the molded impression **402** as shown in FIG. **10**E. The antennas **414** and **416** interface the side wings **410***a* and **410***b*, respectively. An adhesive is applied to the RFID chip **412** so the chip is fixedly coupled to the center of the compressible core. The antenna **414** and **416** may be single conductive wire or a plurality of stranded wires that are braided.

During manufacturing, a filler material is applied to fill any gaps in the molded impression **402**. The molded shell **406** is then applied. The resulting RFID golf ball **420** has the benefit of having the chip in the center and dampening the impact of being hit by a golf club, and the curved antenna does not possess any sharp turns thereby minimizing breaking the antenna.

Referring to FIGS. **11**A-**11**F, there is shown another embodiment with an RFID integrated circuit disposed on the surface of a compressible core. FIG. **11***a* presents a top view of a ruggedized RFID integrated circuit **432** located within a molded impression on the surface of compressible core **436**. The RFID integrated circuit includes contactless pads (not shown) or "leads" that are soldered to conductive wires **438** on a first side, and conductive wires **440** on an opposite side that operate as antennas. Additionally, a non-conductive material such as an epoxy can be used to further join or better secure the soldered side of the RFID package to the antennas **438** and **440**.

Referring to FIG. **11**B, there is shown a side view of the RFID integrated circuit **432** on the surface of the compressible core **436**. A portion of an exterior molded shell **442** is also visible. The conductive wires **438** and **440** are shown to extend approximately half way along the surface of the compressible core **436**.

By way of example and not of limitation, the RFID integrated circuit **432** is a Monzan RFID chip or Monza Dura, which is packaged in a ruggedized tag packaged format with leads as shown above in FIG. **1**B. The Monza Dura is an Impinj chip that is a fully EPC global-compliant, high-performance, Monza-powered tag with printed circuit board (PCB) applications and enabled ruggedized tag design.

In the illustrative embodiment, the antennas **438** and **440** are soldered to RFID package leads in a wire pattern shown in FIGS. **11**C and **11**D, and a loop pattern shown in FIGS. **11**E and **11**F. The conductive wires or antennas may be a single wire or a plurality of stranded wire. In the illustrative embodiment, the plurality of stranded wires is a braided wire that may be used to lessen the chance for a fatigue failure of a single-wire antenna.

In FIG. **11**C, the illustrative RFID chip **432** includes a plurality of contacts pads such as contact **450**. Contact **450** has a relatively small footprint of approximately 0.3 mm by 0.3 mm. This relatively small footprint has to be electrically coupled to antennas **438** and **440**. The antennas **438** and **440** are composed of conductive wire. By way of example and not of limitation, the conductive wire is a fine copper wire having a diameter of approximately 0.03 mm. The illustrative braided wire can be more generally referred to as stranded wire. Stranded wire is more flexible than solid wire of the same cross-sectional area. Additionally, stranded wire provides hire resistance to metal fatigue.

The illustrative RFID chip **432** is encased in dual flat no (DFN) lead style of packaging that has no pins or wires, but uses contact pads instead. The illustrative material encasing the RFID chip **432** is a rigid material such as a polyamide epoxy material with the contacts **450** exposed.

The antennas and chips are matched so as to optimally function at appropriate frequencies and generally only at the tuned frequency. The most common frequencies are low frequency (LF), high frequency (HF) and ultra high frequency (UHF).

In FIG. **11**C the antennas **438** and **440** are configured as a dampened waveform, in which the amplitude of the sinusoidal waves decrease as a function of the distance from the RFID chip **432**. In FIG. **11**D, the antennas **438** and **440** are configured as a waveform, in which the amplitude of the sinusoidal waveforms remain constant as a function of the distance from the RFID chip **432**. In both embodiments shown in FIGS. **11**C and **11**D, the conductive wires or antennas **438** and **440** may be single conductive wire or multiple stranded wires that may be braided.

In FIGS. **11**E and **11**F two different "figure-eight" embodiments are shown. More particularly, in FIG. **11**E there is shown a planar embodiment where the ends of the conductive wires **438** terminate at on the same side **444** of the RFID chip **432**; and on the opposite side **446**. The conductive wires **440** terminate on the same side **446**.

In FIG. **11**F, a first end of the conductive wire **438** is electrically coupled to one of the contact pads on side **444** and the second end of conductive wire **438** is coupled one of the contacts pads on the opposite side **446**. Additionally, the ends of conductive wire **440** also terminate on side **444** and **446**. The resulting "figure-eight" is not planar, and although with the appropriate molded impression the RFID chip may reside on the surface of the compressible core **436**, this figure-eight embodiment may also be located in the center of the compressible core **436**.

Referring to FIG. **12**A-**12**D there is shown an exploded view of an encapsulated RFID chip joined or fixedly coupled to at least one conductive wire. In FIG. **12**A, the illustrative RFID chip **450** is shown to be packaged in a secondary protective package **452** or "encapsulation material" that is then connected to an antenna as described herein.

Alternatively, the RFID chip **450** may mounted on a circuit board that is then communicatively coupled to an antenna (not shown). For example, RFID chip **450** may be mounted on a circuit board and have enhanced mechanical, electrical and thermal performance.

The selection of the encapsulation material may be dependent on the amount of vibration that is necessary to dampen the impact the golf club hitting the golf ball. By way of example and not of limitation, a material with a high dampening capacity may be silicon or include a silicon-based material. Thus, the encapsulation material may be silicon based and flexible. Alternatively, the encapsulation material may be more rigid, i.e. have a low dampening capacity, and for illustrative purposes is a polyamide epoxy.

After the RFID chip **450** is placed in the secondary protective package **452**, the chip **450** is connected to an antenna. In FIG. **12**A there is shown an exploded view of a plurality of stranded wires joined to the contact pads **454**, **456**, **458** and **460**. For illustrative purposes, the remaining contact pads are not operable and are not electrically coupled to the RFID chip **450**.

The contact pads **454**, **456**, **458** and **460** are each fixedly coupled to antennas **462**, **464**, **466** and **468**, respectively, with a solder, i.e. conductive material. The solder material **470**, **472**, **474** and **476** joins the conductive wire or wires to the contact pads **454**, **456**, **458** and **460**, respectively. The illustrative solder material may be 96% Sn and 4% Pb. Alternatively, the solder may include silver at 7%. By way of example, the tensile stress on the on the solder joint may be approximately 15 psi.

Additionally, the solder may be combined with a non-conductive material such as an epoxy resin that can further absorb the impact of the golf club striking the golf ball. By way of example and not of limitation, the epoxy resin dots **478**, **480**, **482** and **484** cover the each of the contacts that have been soldered to the conductive wires.

The illustrative antennas **462**, **464**, **466** and **468** are composed on one or more copper wires. The plurality of conductive wires are also referred to as stranded wires. In the illustrative embodiment, the stranded wires are be intertwined or braided.

Referring to FIG. **12**B, there is shown an exploded view of the encapsulated RFID chip **450**, in which the contacts **454**, **456**, **458** and **460** are first electrically coupled to a thicker wire **486**, **488**, **490** and **492** that interfaces with the contact pads. The thicker wire **486**, **488**, **490** and **492** are shown in two configurations. In each configuration, the thicker wires **486**, **488**, **490** and **492** increase the surface area of the contact pads, thereby simplifying the welding process and providing greater surface area for a non-conductive adhesive. In FIG. **12**C, a stamped thicker wire **494** is shown having a 90° angle. And in FIG. **12**C, the thicker wire **496** is curved. After the thicker wires shown in FIGS. **12**B-**12**D are joined to the contact pads **454**, **456**, **458** and **460**, the conductive wires **462**, **464**, **466**, and **468** are then fixedly coupled, i.e. joined, to the thicker wires.

An alternative to the conductive wires described above includes the use of conductive ink instead of conductive wires. The conductive ink can be printed directly on compressible ball or on to a carrier medium that is then joined to the compressible ball. The conductive ink may be composed of materials such as graphene, silver flakes, nanoparticles and other such materials. By way of example and not of limitation, silver flake ink can be purchased from DuPont and requires a binder to bind the silver flakes.

In each of the embodiments described above, the tensile stress, tensile strain, and elasticity also affect the RFID integrated circuit, antenna, and means for joining the RFID integrated circuit to the antenna, e.g. a solder joint. Thus, depending on the material properties of the encapsulating material for the RFID chip, the material properties of the solder joint, e.g. stress on the solder, must also be considered. Additionally, the solder may also be combined with other materials such as an epoxy resin. The combination of materials affects the stress and strain at each solder joint, and the elastic modules corresponding to the solder joint. Thus, the engineering design is dependent on the material properties of the material encapsulating the RFID chip, the contacts on the RFID chip, the antenna wire, and solder joint that fixedly couples the antenna wire to the RFID chip contacts.

Referring now to FIG. **13**, an illustrative system diagram **500** for the golf range target system is shown. In the illustrative embodiment, the player obtains a set of RFID golf balls dispensed by a golf ball dispenser such as that shown at **100** or **120** in FIG. **3**. An issuing area RFID reader **502** may be a component of the golf ball dispenser, or may be located elsewhere at the driving range. The RFID golf balls are placed in or dispensed to an indicated designated area proximate to the issuing area RFID reader. Each RFID golf ball has a unique identification stored on the RFID transponder embedded within the ball. The issuing area RFID reader reads the unique identification from each of the plurality of balls. The issuing area RFID reader is communicatively coupled to an issuing area network communications module **514**. The network communications module is a transmitter which sends a signal to another device on a network. The network may be, for example, a local area network or wide area network. The identification of each RFID golf ball in the player's set of RFID golf balls as detected by the issuing area RFID reader **502** is sent to server **504** via issuing area first network communications module **514**. The server creates an entry in database **506** associating the identifications of the plurality of RFID golf balls with a unique identification associated with the player. The server and database may be located on site at the driving range. In some embodiments, the server or database or both the server and the database are located off site and receive communications from the RFID readers over, for example, a LAN or WAN. The server and database may be located in the same physical computer. Alternatively, an on-site server may be configured to communicate with an off-site server and database. Multiple databases may be used in conjunction with the one or more servers located on-site, off-site, or both. A multiple-site driving range establishment may use multiple servers to allow information to be collected from and distributed to the multiple sites.

The database may be configured to store additional information associated with a player including, but not limited to, a record of the player's play history at the driving range, transactional information, and account information. The player ID and other information associated with the player may be stored on a card having a magnetic stripe or other readable media. Alternatively, the player may be issued a PIN number or username and password combination associated with the player ID. In some embodiments, a temporary player account is created for short term use of the driving range. The player may receive a paper voucher indicating a temporary player ID in human readable and/or barcode form. A paperless system for issuing a temporary player ID may involve communicating the player ID to the player visually or audibly, or associating a particular tee box with the player's set of RFID golf balls.

At the tee area, the player removes a ball from the set of RFID golf balls and places it on a tee in preparation for hitting the ball onto the driving range. The identification of the individual golf ball is obtained by tee area RFID reader **508** and sent to server **504** via a tee area network communications module **516** communicatively coupled to the tee area RFID reader. The communication of an RFID golf ball identification from the tee area network communications module to the server may occur when the ball is placed on the tee (on arrival at the tee area), or when the ball is hit off of the tee (on departure from the tee area). In some embodiments, the identification of the RFID golf ball is communicated when the ball is placed on the tee and again when it is hit from the tee area.

It is to be understood that the detailed description of illustrative embodiments are provided for illustrative purposes. The scope of the claims is not limited to these specific embodiments or examples. Therefore, various process limitations, elements, details, and uses can differ from those just described, or be expanded on or implemented using technologies not yet commercially viable, and yet still be within the inventive concepts of the present disclosure. The scope of the invention is determined by the following claims and their legal equivalents.

What is claimed is:

1. An RFID golf ball system comprising:

an RFID golf ball including,

an RFID integrated circuit that includes a plurality of RFID contact pads and an RFID memory configured to store at least one unique identifier,

an RFID antenna electrically coupled to the RFID Integrated circuit, wherein the RFID antenna includes a plurality of stranded wires that are fixedly coupled to the RFID contact pads,

a compressible core having a center and a spherical surface, wherein the compressible core includes an impression on the surface of the compressible core,

a flexible substrate that encapsulates the RFID integrated circuit, wherein the flexible substrate having the encapsulated RFID integrated circuit received by the impression includes Teslin,

a shell that encapsulates the compressible core generating an RFID golf ball, wherein the shell interfaces with the compressible core and the flexible substrate having the encapsulated RFID integrated circuit; and

an RFID reader antenna disposed near a tee area, wherein the RFID reader antenna is configured to read the unique identifier associated with the RFID golf ball.

2. The RFID golf ball system of claim **1** wherein the flexible substrate encapsulating the RFID integrated circuit includes Teslin.

3. The RFID golf ball system of claim **1** wherein the plurality of stranded wired are braided.

4. The RFID golf ball system of claim **1** further comprising a fill material that fills the impression occupied by the flexible substrate.

5. The RFID golf ball system of claim **1** wherein the impression comprises a planar slot disposed in the center of the compressible core, the planar slot configured to receive the flexible substrate.

6. The RFID golf ball system of claim **3** wherein the flexible substrate encapsulating the RFID integrated circuit includes Teslin.

7. The RFID golf ball system of claim **1** wherein the RFID antenna is electrically coupled to the RFID integrated circuit with a non-conductive adhesive.

8. A method for reading an RFID golf ball comprising:

dispensing an RFID golf ball within a driving range, wherein the RFID golf ball includes,

an RFID integrated circuit that includes a plurality of RFID contact pads and an RFID memory configured to store at least one unique identifier,

an RFID antenna electrically coupled to the RFID integrated circuit, wherein the RFID antenna includes a plurality of stranded wires that are fixedly coupled to the RFID contact pads,

a compressible core having a center and a spherical surface, wherein the compressible core includes an impression on the surface of the compressible core,

a flexible substrate that encapsulates the RFID integrated circuit, wherein the flexible substrate having the encapsulated RFID integrated circuit received by the impression includes Teslin,

a shell that encapsulates the compressible core generating an RFID golf ball, wherein the shell interlaces with the compressible core and the flexible substrate having the encapsulated RFID integrated circuit; and

reading the RFID golf ball within a driving bay with at least one RFID reader.

9. The RFID ball reading method of claim **8**, wherein the RFID reader includes an RFID reader antenna that is disposed above ground along a vertical plane.

10. The RFID ball reading method of claim **8**, wherein the RFID reader includes an RFID reader antenna that is disposed along a horizontal plane.

11. The RFID ball reading method of claim **8** wherein each RFID reader is communicatively coupled to a plurality of antennas, in which each antenna corresponds to a particular golf driving bay.

12. The RFID ball reading method of claim **8** wherein a plurality of RFID readers are networked and communicate RFID data to a central database.

13. The RFID ball reading method of claim **8** wherein the flexible substrate encapsulating the RFID integrated circuit includes Teslin.

14. The RFID ball reading method of claim **13** wherein the RFID antenna is electrically coupled to the RFID integrated circuit with a non-conductive adhesive.

15. The RFID ball reading method of claim **8** wherein the plurality of stranded wires for the RFID antenna are braided.

* * * * *